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MATHÉMATIQUES

SUR LES LIGNES SUR LA SURFACE DONT LA TORSION GÉODÉSIQUE ET LA COURBURE NORMALE SONT LIÉES PAR UNE RELATION LINÉAIRE

Par N. G. TOUGANOFF

(Présenté par N. N. Lusin, de l'Académie, le 8. VII. 1938)

I. Origine géométrique des lignes $a\cdot\frac{1}{T_g}+b\cdot\nu=c$ (*).

Examinons un couple de lignes L, L', situées respectivement sur les surfaces S, S' et dont la normale à S au point de L coïncide avec celle de S' au point homologue de L', les trièdres homologues de S, S' étant invariablement liés. Les lignes L, L' sont caractérisées par l'équation:

$$\frac{\operatorname{ctg}\psi}{T_g}-\nu=\frac{1}{d},$$

ou $\frac{1}{T_g}$ est la torsion géodésique de L, ν est la courbure normale, d — la distance entre les points homologues de L, L'.

Inversement, si une ligne L sur S est telle que la torsion géodésique et la courbure normale sont liées par une relation (*), il existe une ligne L' sur S' telle, que les normales de S, S' aux points homologues de L, L' coïncident et les trièdres homologues de S, S' sont liés invariablement.

Cas particuliers:

1. Si la ligne conjuguée L' se trouve dans l'infini, la ligne L est une «hélice de surface», caractérisée par la relation $\frac{1}{T_g}:\nu=\text{const}$.

2. Si $\psi=90°$, on a $\nu=\text{const}$. En particulier, si $\psi=90°$ et $d=\infty$, on obtient les lignes asymptotiques.

3. Si $\psi=0$, on obtient les lignes de courbure de la surface.

4. Si $d\to 0$ et $\psi\to 0$ et $\lim\limits_{\substack{\psi\to 0\\ d\to 0}}\frac{\operatorname{tg}\psi}{d}=\text{const}$, on obtient des lignes $\frac{1}{T_g}=\text{const}$.

II. Les propriétés des lignes $a\cdot\frac{1}{T_g}+b\cdot\nu=c$ (*) *sur la surface.*

1. Les lignes (*) sur une surface S forment un réseau, dont l'équation en fonction des paramètres u, v de lignes de courbure de S est

$$E\cdot\left(\frac{b}{R_2}-c\right)du^2+a\cdot\sqrt{Eg}\cdot\left(\frac{1}{R_1}-\frac{1}{R_2}\right)du\,dv+g\cdot\left(\frac{b}{R_1}-c\right)dv^2=0,$$

où E, g sont les coefficients de l'élément linéaire de S et R_1, R_2 sont des rayons des courbures principales.

2. Soient θ et ϑ somme algébrique des angles, formés par deux lignes de réseau (*) avec les lignes de courbure de S, qui passent par le point approché de S. On a sur toute la surface S $\theta+\vartheta=\psi$.

3. Il existe entre les courbures normales des lignes du réseau (*) des relations:

$$\nu_1+\nu_2=\frac{a^2}{a^2+b^2}\cdot I+\frac{2bc}{a^2+b^2}, \qquad \nu_1\cdot\nu_2=\frac{a^2}{a^2+b^2}\cdot K+\frac{c^2}{a^2+b^2},$$

où I et K sont les courbures moyenne et totale de S.

4. La courbure normale de S dans n'importe quelle direction s'exprime au moyen des courbures normales des lignes du réseau $\frac{1}{T_g}=p$ par la relation $\frac{1}{R}=\frac{\sin^2\delta}{r_1}+\frac{\cos^2\delta}{r_2}+p\cdot\sin 2\delta$, où δ est l'angle, formé par la direction considérée avec la direction d'une ligne $\frac{1}{T_g}=p$. Si $p=0$, on obtient la formule d'Euler: $\frac{1}{R}=\frac{\sin^2\vartheta}{R_1}+\frac{\cos^2\vartheta}{R_2}$.

5. Sur les surfaces $R_1+R_2=\frac{2b}{c}$ le réseau (*) est conjugué.

Conséquence. Sur la surface développable les lignes $\frac{1}{T_g}:\nu=\text{const}$ coupent les génératrices rectilignes sous l'angle constant.

6. Sur les surfaces $\frac{1}{R_1}+\frac{1}{R_2}=\frac{2c}{b}$ le réseau (*) est orthogonal. En particulier, le réseau $\frac{1}{T_g}:\nu=\text{const}$ est orthogonal sur les surfaces minima.

7. Les lignes du réseau (*) traversent les lignes de courbure sous l'angle constant sur les surfaces, qui ont les courbures principales liées par la relation linéaire.

8. Sur les surfaces $\frac{A}{R_1}-\frac{1}{R_2}=\frac{c}{b}\cdot(A-1)$, où $A=\text{const}$, la représentation des lignes (*) sur les deux nappes de la développée est un système conjugué.

9. Sur les surfaces

$$\frac{\sqrt{R_2-\frac{b}{c}}+\sqrt{R_2}}{\sqrt{R_1-\frac{b}{c}}+\sqrt{R_1}}=\text{const},$$

$$\left(\sqrt{R_2-\frac{b}{c}}+\sqrt{R_2}\right)\left(\sqrt{R_1-\frac{b}{c}}+\sqrt{R_1}\right)=\text{const}$$

(et rien que sur elles parmi les surfaces W) la représentation du réseau (*) sur les deux nappes de la développée est un système orthogonal.

En particulier, pour les surfaces $K=\text{const}$ et $\frac{R_2}{R_1}=\text{const}$ la représentation de n'importe quel réseau $\frac{1}{T_g}=\text{const}$ sur les deux nappes de la développée est un système orthogonal.

Remarque. *Le problème général est de trouver une ligne L sur la surface dont le trièdre, formé de la normale à S, de la tangente t à la ligne et de la tangente orthogonale n de S, est lié invariablement avec le trièdre homologue de la ligne adjointe L'.*

En particulier, si les arêtes n, n' de deux trièdres homologues de L, L' coïncident, on obtient

$$a\cdot\frac{1}{T_g}+b\cdot\frac{1}{\rho_g}=c.$$

L'exposé de ces résultats sera donné par l'auteur dans l'avenir prochain.

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MATHÉMATIQUES

SUR LA STRUCTURE DES GROUPES SIMPLES

PAR W. TURKIN ET P. DUBUQUE

(Présenté par O. J. Schmidt, de l'Académie, le 28. VI. 1938)

Dans l'article «Les quasi-normalisateurs et les représentations monomiales» le théorème suivant a été démontré par W. Turkin.

«Soit $\mathfrak{G}$ un groupe d'ordre $p^{\alpha}n$ (p étant un nombre premier impair, $p(p-1)$ n'ayant pas de facteur commun avec n). Soit A un élément de l'ordre p^k du groupe $\mathfrak{G}$. Si l'ordre du normalisateur de l'élément $A^{p^{k-1}}$ par rapport au groupe $\mathfrak{G}$ n'est pas divisible par p^{2k}, le groupe $\mathfrak{G}$ admet un diviseur normal, dont l'ordre est divisible par n».

En utilisant la méthode appliquée par W. Turkin dans l'article cité, on peut obtenir la proposition plus générale, que nous exposons plus bas.

Théorème 1. *Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre p^{α} d'un certain groupe $\mathfrak{G}$ d'ordre $p^{\beta}n$ (p est un nombre premier impair, et n n'est pas divisible par p). Soit A un élément du sous-groupe $\mathfrak{P}$ d'ordre p^k, chaque élément $\mathfrak{P}$ conjugué de A^z étant égal à A^{mz}, où $m \equiv 1 \pmod{p}$. Si l'ordre du normalisateur de l'élément $A^{p^{k-1}}$ n'est pas divisible par $p^{\alpha+k}$, le groupe $\mathfrak{G}$ a un diviseur normal dont l'ordre est divisible par n.*

En particulier, si $\mathfrak{P}$ est un groupe cyclique, on a $\alpha = k$ et nous obtenons un théorème qui complète la proposition citée de W. Turkin.

Le théorème 1 renferme aussi, comme cas particulier, la proposition suivante, bien connue, de Burnside (pour p impair).

Si un sous-groupe de Sylow de l'ordre p^{α} du groupe $\mathfrak{G}$ de l'ordre $p^{\beta}n$ (n n'étant pas divisible par p) appartient au centre de son normalisateur, le groupe $\mathfrak{G}$ admet un diviseur normal de l'ordre divisible par n.

En effet, si $\mathfrak{P}$ est un sous-groupe de Sylow d'ordre p^{β} appartenant au centre de son normalisateur, le groupe $\mathfrak{P}$ est un groupe abélien, et on peut prendre en qualité d'élément A chaque élément de ce groupe (car d'après un théorème de Burnside, quels que soient deux éléments du groupe $\mathfrak{P}$, ils ne sont pas conjugués entre eux). Par conséquent, dans ce cas les conditions du théorème 1 sont nécessairement vérifiées.

Le théorème 1 contient d'ailleurs (pour p impair) la proposition suivante, démontrée par P. Dubuque.

Soit $\mathfrak{P}$ un sous-groupe de Sylow d'ordre p^{α} d'un certain groupe $\mathfrak{G}$ d'ordre $p^{\beta}n$. Soit d'ailleurs H un élément d'ordre p^l d'un groupe abélien $\mathfrak{H}$ d'ordre p^k, faisant partie du groupe $\mathfrak{P}$. Si aucune puissance de l'élément H n'est conjuguée à aucun élément du groupe $\mathfrak{H}$, le normalisateur

de l'élément H coïncide avec le normalisateur de l'élément $H^{p^{l-1}}$ et $k+l>\alpha$, le groupe $\mathfrak{G}$ admet un diviseur normal dont l'ordre est divisible par n.

Indiquons les points principaux de la démonstration du théorème 1. Soit

$$\mathfrak{G}=\mathfrak{P}+\mathfrak{P}G_2+\ldots+\mathfrak{P}G_s \tag{1}$$

et

$$G_\lambda A=P^{(\lambda)}G_{i_\lambda} \tag{2}$$

ou $P^{(\lambda)}$ est un élément du sous-groupe $\mathfrak{P}$.

D'après le théorème de Turkin (1), on peut conclure que si le produit

$$P^{(1)}P^{(2)}\ldots P^{(s)} \tag{3}$$

n'est pas égal à l'unité, le groupe $\mathfrak{G}$ a un diviseur normal dont l'ordre est divisible par n. En calculant le produit (3) il ne faut considérer que ceux des éléments $P^{(i)}$ qui correspondent — au sens de l'égalité (2) — aux résidus de la décomposition (1) qui appartiennent au normalisateur de l'élément $A^{p^{k-1}}$.

Soit $\mathfrak{A}$ un certain sous-groupe du groupe $\mathfrak{G}$ contenant le groupe $\mathfrak{P}$. Soit

$$\mathfrak{A}=\mathfrak{P}+\mathfrak{P}A_1+\ldots+\mathfrak{P}A_l$$

et

$$A_\lambda A=P^{(\lambda)}A_{i_\lambda}.$$

Désignons le produit $P^{(1)}P^{(2)}\ldots P^{(l)}$ par $\Pi(\mathfrak{A}, A)$. Désignons ensuite par $\mathfrak{N}_B^{(\lambda)}$ le λ-ième quasi-normalisateur * d'un certain élément B dont l'ordre est une puissance du nombre premier p.

Enfin, désignons par λ_i la valeur maxima du nombre λ pour laquelle $\mathfrak{N}_{A^{p^i}}^{(\lambda)}=\mathfrak{N}_{A^{p^i}}^{(1)}$. Dans ces notations le problème se réduit au calcul du produit $\Pi(\mathfrak{N}_{A^{p^{k-1}}}^{(1)}, A)$.

Les propositions données dans la suite s'appuient sur les deux lemmes suivants.

Lemme 1. *Soit v le rapport des ordres des groupes $\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}$ et $\mathfrak{N}_{A^{p^i}}^{(\lambda_i)}$. Alors on a:*

$$\Pi(\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}, A)=[\Pi(\mathfrak{N}_{A^{p^i}}^{(\lambda_i)}, A)]^v.$$

Remarque. Si $\lambda_i=k-i$, on suppose que

$$\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}=\mathfrak{N}_{A^{p^{i+1}}}^{(k-i-1)}.$$

Lemme 2. *Si $\mathfrak{N}_{A^{p^i}}^{(\lambda)}\neq\mathfrak{N}_{A^{p^i}}^{(\lambda-1)}$ et $\lambda\leqslant\lambda_{i-1}$, on a:*

$$\Pi(\mathfrak{N}_{A^{p^i}}^{(\lambda-1)}, A)=[\Pi(\mathfrak{N}_{A^{p^i}}^{(\lambda)}, A)]^z, \quad \text{où } z\equiv p \pmod{p^2}.$$

Il est facile à voir que

$$\Pi(\mathfrak{N}_A^{(k)}, A)=A^z,$$

---

* La définition du quasi-normalisateur et les théorèmes fondamentaux sur les quasi-normalisateurs sont donnés dans l'article de W. Turkin «Ueber Quasinormalisatoren der Elemente in endlichen Gruppen» (2).

où Z est le rapport des ordres des groupes $\mathfrak{N}_A^{(k)}$ et $\mathfrak{P}$. Supposons que le rapport des ordres des groupes $\mathfrak{N}_{Ap^{k-1}}^{(1)}$ et $\mathfrak{N}_A^{(k)}$ soit égal à $p^\omega\varphi$, où φ n'est pas divisible par p.

En appliquant d'une manière convenable les lemmes précédents, on arrive enfin à la conclusion que

$$\Pi\,(\mathfrak{N}_{Ap^{k-1}}^{(1)}, A) = A^{Z\xi}$$

en notant que

$$\xi \equiv 0 \pmod{p^\omega} \not\equiv 0 \pmod{p^{\omega+1}}.$$

Le groupe $\mathfrak{G}$ ne peut être simple qu'au cas où le produit $\Pi\,(\mathfrak{N}_{Ap^{k-1}}^{(1)}, A)$ est égal à l'unité, autrement dit, si le rapport des ordres des groupes $\mathfrak{N}_{Ap^{k-1}}^{(1)}$ et $\mathfrak{P}$ est divisible par p^k et si l'ordre du groupe $\mathfrak{N}_{Ap^{k-1}}^{(1)}$ est divisible par $p^{k+\alpha}$.

P. Dubuque a prouvé pour le cas $p=2$ le théorème suivant:

«Soit $\mathfrak{G}$ un groupe d'ordre $2^\alpha n$ (n étant impair). Soit A un élément d'ordre 2^k du groupe $\mathfrak{G}$. Si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse, et si l'ordre du normalisateur de l'élément $A^{2^{k-1}}$ n'est pas divisible par 2^{2k}, le groupe $\mathfrak{G}$ admet un diviseur normal dont l'ordre est divisible par n. Il se trouve possible de démontrer une proposition plus générale qui est en même temps un supplément du théorème 1.

Théorème 2. *Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre 2^α d'un certain groupe $\mathfrak{G}$ d'ordre $2^\beta n$ (n étant impair). Soit A un élément du sous-groupe $\mathfrak{P}$ d'ordre 2^k, tout élément $\mathfrak{P}$ conjugué à une certaine puissance de A sera encore une puissance de A.*

Si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse et si l'ordre du normalisateur de l'élément $A^{2^{k-1}}$ n'est pas divisible par $2^{k+\alpha}$, le groupe $\mathfrak{G}$ a un diviseur normal dont l'ordre est divisible par n.

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MATHÉMATIQUES

UN THÉORÈME CONTENANT DES THÉORÈMES DE FROBENIUS, DE WEISNER ET DE TURKIN SUR LE NOMBRE DES ÉLÉMENTS D'UN ORDRE DONNÉ DANS UN GROUPE

Par P. DUBUQUE

(Présenté par O. J. Schmidt, de l'Académie, le 28.VI.1938)

Dans l'article «Sur le nombre d'éléments d'un groupe satisfaisant à certaines conditions» l'auteur a démontré le théorème suivant:

Soient a et m les ordres des éléments, appartenant respectivement aux classes d'éléments conjugués $\mathfrak{A}$ et $\mathfrak{M}$ du groupe $\mathfrak{G}$. Soit ensuite n un diviseur de l'ordre du groupe $\mathfrak{G}$, premier avec a et multiple de m. Le nombre des éléments du groupe $\mathfrak{G}$, dont la n-ième puissance appartient à la classe $\mathfrak{A}$ et dont une certaine puissance appartient à la classe $\mathfrak{M}$, est divisible par le plus grand diviseur de n, premier avec m.

En faisant quelques modifications dans la méthode appliquée dans l'article cité, on peut obtenir le résultat suivant plus général.

Théorème 1. *Soient a et m les ordres des éléments appartenant respectivement aux classes d'éléments conjugués $\mathfrak{A}$ et $\mathfrak{M}$ du groupe $\mathfrak{G}$. Soit d'ailleurs n un diviseur de l'ordre du groupe $\mathfrak{G}$ qui est un multiple de m. Alors le nombre des éléments du groupe $\mathfrak{G}$, dont la n-ième puissance appartient à la classe $\mathfrak{A}$ et dont une certaine puissance appartient à la classe $\mathfrak{M}$, est divisible par le plus grand diviseur de n, premier avec m.*

En particulier, si les nombres a et n sont premiers entre eux, nous obtenons le théorème précédemment cité.

Si dans les conditions du théorème 1 on pose $m=1$, la classe $\mathfrak{M}$ se réduit à l'unité et nous obtenons une proposition bien connue de Frobenius (1).

Le nombre des éléments du groupe $\mathfrak{G}$, dont la n-ième puissance appartient à une classe donnée d'éléments conjugués $\mathfrak{A}$, est un multiple de n.

D'autre part, en posant $a=1$ et n égal à l'ordre du groupe $\mathfrak{G}$, on arrive au théorème qui a été obtenu en 1925 par un savant américain L. Weisner (2):

Soit m l'ordre d'un élément dans la classe $\mathfrak{M}$ des éléments conjugués du groupe $\mathfrak{G}$. Le nombre des éléments du groupe, dont une certaine puissance appartient à la classe $\mathfrak{M}$, est un multiple du plus grand diviseur de l'ordre du groupe premier avec m.

Enfin comme conséquence du théorème 1, on peut obtenir* le théorème connu de W. Turkin (4).

Soient n et m les diviseurs de l'ordre du groupe, n étant un multiple de m. Le nombre des éléments du groupe, dont l'ordre est un diviseur de n et un multiple de m, est divisible par le plus grand diviseur de n premier avec m.

Notons les points principaux de la démonstration du théorème 1.

Nous nous proposons de déterminer le nombre des éléments x du groupe $\mathfrak{G}$, satisfaisants aux deux conditions:

$$x^n \subseteq \mathfrak{A}, \tag{1}$$

$$x^\alpha \subseteq \mathfrak{M}, \tag{2}$$

α pouvant être choisi d'une manière quelconque.

Posons $n = la'$, où l est le plus grand diviseur de n premier avec a'. Il suit de (1), que l'ordre de tout élément, satisfaisant aux conditions posées, doit être divisible par aa'. Soit $a' = a_1 r$, où a_1 est le plus grand diviseur de a' premier avec m.

Il résulte de (2), que α doit être divisible par a_1. Maintenant on peut remplacer les conditions (1) et (2) par les conditions suivantes:

$$x^{a_1} = z, \tag{3}$$

$$z^{lr} \subseteq \mathfrak{A}, \tag{4}$$

$$z^\beta \subseteq \mathfrak{M}, \tag{5}$$

où le choix de β est arbitraire.

En effet, si un élément x quelconque satisfait aux conditions (1) et (2), il satisfaira de même à la condition (3) avec les conditions supplémentaires (4) et (5). Inversement, si un élément x satisfait à la condition (3), les conditions (4) et (5) étant vérifiées, x doit aussi satisfaire aux conditions (1) et (2).

Désignons les éléments z satisfaisant aux conditions (4) et (5) par

$$z_1, z_2, \ldots z_s.$$

Déterminons le nombre des éléments x, satisfaisants à l'une des conditions

$$x^{a_1} = z_1, x^{a_1} = z_2, \ldots, x^{a_1} = z_s.$$

L'ensemble des éléments $z_1, z_2, \ldots, z_s$ représente, comme il résulte facilement des conditions (4) et (5), un complexe invariant d'éléments du groupe $\mathfrak{G}$.

Le nombre des éléments x, satisfaisants aux conditions posées, sera, par conséquent, en vertu du théorème de Frobenius, un multiple de a_1.

En se servant encore des méthodes appliquées par l'auteur dans les articles cités ci-dessus, on peut montrer que le nombre des éléments d'un groupe, satisfaisants aux conditions posées, sera également un multiple du plus grand diviseur du nombre l premier avec m. Comme l et a sont premiers entre eux, il en résulte, que le nombre des éléments d'un groupe, satisfaisants aux conditions posées, est divisible par le plus grand diviseur de n premier avec m.

Une méthode analogue nous permettra aussi de démontrer le théorème suivant:

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* Voir l'article de l'auteur «Sur le théorème de Frobenius» (3).

Théorème 2. *Soit a l'ordre d'un élément dans la classe $\mathfrak{A}$ d'éléments conjugués du groupe $\mathfrak{G}$ et soit m l'ordre de tous les éléments dans un système arbitraire $\mathfrak{M}$ du groupe $\mathfrak{G}$.*

Soit ensuite n un diviseur de l'ordre du groupe $\mathfrak{G}$ et un multiple du nombre m. Si les nombres a et m sont premiers entre eux, le nombre des éléments du groupe $\mathfrak{G}$, dont la n-ième puissance appartient à la classe $\mathfrak{A}$, et une certaine puissance appartient au système $\mathfrak{M}$, est un multiple de $\varphi(m)$.

On peut, comme suite des théorèmes 1 et 2, obtenir le résultat suivant:

Théorème 3. *Soit a l'ordre d'un élément dans la classe $\mathfrak{A}$ d'éléments conjugués du groupe $\mathfrak{G}$. Soit ensuite n un diviseur de l'ordre du groupe $\mathfrak{G}$ multiple d'un certain nombre m premier avec a. Alors le nombre des éléments du groupe $\mathfrak{G}$, dont l'ordre est un multiple de m et satisfaisant à la condition $x^n \subset \mathfrak{A}$, est divisible par le plus grand diviseur de n premier avec m et de plus divisible par $\varphi(m)$.*

Le théorème 3 contient comme cas particulier la généralisation suivante d'un théorème de W. Turkin, indiquée par l'auteur [5] dans l'article «La généralisation du théorème de Turkin».

Soient n et m des diviseurs de l'ordre d'un groupe donné, n étant multiple de m, par conséquent:

$$n = a_1^{\alpha_1} a_2^{\alpha_2} \dots a_k^{\alpha_k} b_1^{\alpha_{k+1}} b_2^{\alpha_{k+2}} \dots b_l^{\alpha_{k+l}},$$
$$m = a_1^{\beta_1} a_2^{\beta_2} \dots a_k^{\beta_k},$$

où tous les a_i et b_i sont des nombres premiers et pour tous les i, $\beta_i \leqslant \alpha_i$.

Alors le nombre des éléments d'un groupe, dont l'ordre est un diviseur de n et un multiple de m, est divisible par le nombre

$$a_1^{\beta_1 - 1} a_2^{\beta_2 - 1} \dots a_k^{\beta_k - 1} b_1^{\alpha_{k+1}} b_2^{\alpha_{k+2}} \dots b_l^{\alpha_{k+l}}.$$

En partant du théorème 1 on peut également déduire le théorème suivant.

Théorème 4. *Soit n et m des diviseurs de l'ordre du groupe $\mathfrak{G}$, n étant un multiple de m. Le nombre des éléments du groupe, dont l'ordre est un multiple de m, et dont la n-ième puissance appartient à une classe arbitraire $\mathfrak{A}$ d'éléments conjugués du groupe $\mathfrak{G}$, est un multiple du plus grand diviseur de n premier avec m.*

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MATHÉMATIQUES

SUR LA DÉFORMATION DES SURFACES DE ROTATION FERMÉES ET OUVERTES À COURBURE NÉGATIVE AVEC LES ARÊTES CIRCULAIRES

Par V. LUKCHIN

(Présenté par N. N. Lusin, de l'Académie, le 8.VII.1938)

L'étude de la déformation infiniment petite des surfaces de révolution à courbure négative avec une ligne singulière, à savoir l'arête circulaire, conduit aux cas: les surfaces ouvertes avec des frontières paraboliques ou ordinaires, les surfaces ouvertes d'un côté ayant un point singulier conique de l'autre côté, enfin, les surfaces fermées possédants deux points singuliers coniques. Pour étudier les déformations des surfaces nous nous servons de la même méthode que dans nos articles précédents. Considérons seulement deux cas.

1. Il y a dans le plan (z, r) une courbe ABC, qui se compose de deux arcs analytiques AB et BC, le point B qui est un point angulaire ou un point de rebroussement se trouve sur l'axe Or à distance $r_0 > 0$ de l'origine; la courbe rencontre l'axe de rotation Oz dans les points: $A(-z_0, 0)$, $C(z_1, 0)$, où $z_0 > 0$, $z_1 > 0$, les convexités des courbes AB et BC sont partout dirigées vers l'axe de rotation; elles possèdent toutes propriétés de la courbe OA de l'article précédent (1). Désignons par S et $\bar{S}$ des surfaces obtenues par la rotation des courbes AB et BC; désignons par $S+\bar{S}$ la surface qui se compose de ces deux surfaces. Supposons qu'elle ait deux points coniques A et C dans lesquels les tangentes au méridien ABC forment avec Oz des angles différents de 0 et de π; la rotation du point B donne l'arête circulaire, et en le considérant comme appartenant à $\bar{S}$ ou à S nous pouvons le supposer ordinaire ou parabolique.

Supposons que les courbes AB et BC sont déterminées par les équations:

la courbe AB:

$$r = r(z) = a(z + z_0) + \varphi(z), \tag{1}$$
$$r'(-z_0) = a > 0, \quad \varphi(-z_0) = \varphi'(-z_0) = 0,$$
$$\varphi(z) > 0; \quad r(0) = az_0 + \varphi(0) = r_0;$$

la courbe BC:

$$\bar{r} = \bar{r}(z) = b(z_1 - z) + \bar{\varphi}(z), \tag{2}$$
$$\bar{r}'(z_1) = -b, \quad b > 0, \quad \bar{\varphi}(z_1) = \bar{\varphi}'(z_1) = 0;$$
$$\bar{\varphi}(z) > 0; \quad \bar{r}(0) = bz_1 + \bar{\varphi}(0) = r_0.$$

La surface de rotation $S+\bar{S}$ est définie par les équations (1) et (2) auxquelles il faut ajouter l'angle de rotation, v, le même pour S et $\bar{S}$, qui varie de 0 à 2π. En considérant a et b comme variables nous obtenons une famille des surfaces $S+\bar{S}$ à un seul paramètre,

$$az_0+\varphi(0)=bz_1+\bar{\varphi}(0). \tag{3}$$

Nous cherchons la surface $S_1+\bar{S}_1$ obtenue de $S+\bar{S}$ par la déformation avec le paramètre de déformation t et alors S se déforme en S_1, $\bar{S}$ se déforme en $\bar{S}_1$, l'arête circulaire de la surface $S+\bar{S}$ se transforme dans cette déformation en une ligne unique de la surface $S_1+\bar{S}_1$.

Supposons que les équations des surfaces S_1 et $\bar{S}_1$ sont:

pour S_1:

$$\left.\begin{aligned} z_1&=z+tZ(z,v),\\ r_1&=r(z)+tR(z,v),\\ v_1&=v+tV(z,v),\end{aligned}\right\} \tag{4}$$

où $-z_0\leqslant z\leqslant 0$, Z, R, V sont des fonctions à déterminer, et

pour $\bar{S}_1$:

$$\left.\begin{aligned} \bar{z}_1&=z+t\bar{Z}(z,v)\\ \bar{r}_1&=\bar{r}(z)+t\bar{R}(z,v),\\ \bar{v}_1&=v+t\bar{V}(z,v),\end{aligned}\right\} \tag{5}$$

où $0\leqslant z\leqslant z_1$, $\bar{Z}, \bar{R}, \bar{V}$ sont des fonctions à déterminer.

Déterminons la déformation de $S+\bar{S}$ comme une correspondance des surfaces $S+\bar{S}$ et $S_1+\bar{S}_1$ telle que l'égalité $ds_1^2-ds^2=0$ doit être vérifiée avec une exactitude de t pour les arcs correspondants des surfaces S et S_1, ainsi que pour les arcs homologues de $\bar{S}$ et $\bar{S}_1$. Pour trouver les fonctions cherchées nous appliquons la méthode de Cohn-Vossen.

Nous obtenons deux systèmes des équations différentielles pour S et $\bar{S}$ respectivement [voir les formules (3) de la Note (1)] d'où les équations

$$rR_n''+(n^2-1)r''R_n=0, \tag{6}$$

$$\bar{r}\bar{R}_n''+(n^2-1)\bar{r}''\bar{R}_n=0, \tag{7}$$

où R_n et $\bar{R}_n$ sont les coefficients des séries de Fourier dans lesquelles R et $\bar{R}$ se développent.

Les fonctions cherchées doivent tout d'abord vérifier les conditions:

$$\left.\begin{aligned} Z(0,v)&=\bar{Z}(0,v),\\ R(0,v)&=\bar{R}(0,v),\\ V(0,v)&=\bar{V}(0,v),\end{aligned}\right\} \tag{8}$$

ensuite les limitations qui s'écoulent de la fixité des points singuliers A et C, et enfin il se peut qu'il y ait des limitations sur la ligne singulière, c'est-à-dire pour $z=0$, ce qui dépend du caractère de cette ligne en la considérant séparément pour S et $\bar{S}$.

Les solutions des équations (6) et (7)

$$R_n(z)=(z+z_0)\,g(a,n;z),$$

$$\bar{R}_n(z)=(z_1-z)\,\bar{g}(b,n;z)$$

vérifient les conditions dans les points singuliers au cas de la déformation de $S+\overline{S}$. Les fonctions cherchées prendront la forme:

$$R(z, v)=\sum_{n=0}^{\infty} R_n(z)\,[C_{n_1}\cos nv + C_{n_2}\sin nv],$$

$$\overline{R}(z, v)=\sum_{n=0}^{\infty} \overline{R}_n(z)\,[\overline{C}_{n_1}\cos nv + \overline{C}_{n_2}\sin nv],$$

où les constantes des intégrations sont différentes de zéro, de même pour les fonctions $Z, \overline{Z}, V, \overline{V}$, où Z et V s'expriment par R à l'aide des formules (5) et (7) de la Note (2).

Les conditions (8) seront satisfaites si l'on exige pour chaque n qu'on ait:

$$\left.\begin{aligned} R_n(0)\,C_{n_1}&=\overline{R}_n(0)\,\overline{C}_{n_1};\quad Z_n(0)\,C_{n_1}=\overline{Z}_n(0)\,\overline{C}_{n_1};\\ R_n(0)\,C_{n_2}&=\overline{R}_n(0)\,\overline{C}_{n_2};\quad Z_n(0)\,C_{n_2}=\overline{Z}_n(0)\,\overline{C}_{n_2}.\end{aligned}\right\} \qquad (9)$$

Cela conduit à la condition suivante:

$$Z_n(0)\,\overline{R}_n(0)=R_n(0)\,\overline{Z}_n(0),$$

ou bien, en exprimant Z_n par R_n, à la condition:

$$\begin{aligned}&(n^2-1)\,R_n(0)\,\overline{R}_n(0)[\overline{r'}(0)-r'(0)]+\\ &+r_0\,[\overline{R}'_n(0)\,R_n(0)-R'_n(0)\,\overline{R}_n(0)]=0.\end{aligned} \qquad (10)$$

Cette équation est satisfaite pour le nombre fini des valeurs de a qui dépend de n. Ainsi la surface $S+\overline{S}$ se déforme seulement pour quelques valeurs de a. Dans certains cas particuliers la condition (10) se simplifie.

Soit la ligne ABC symétrique par rapport à Or: $r'(0)=a+\theta=-r'(\overline{0})$, $R_n(-z)=R_n(\overline{z})$; la condition (10) prend la forme:

$$R_n(0)\,[n^2-1)\,(a+\theta)\,R_n(0)+r_0R'_n(0)]=0,$$

d'où

$$R_n(0)=0,\quad \frac{R'_n(0)}{R_n(0)}=-\frac{(n^2-1)\,(a+\theta)}{r_0}.$$

Comme ces conditions sont satisfaites pour certaines valeurs de $a=a^{(i)}$ et $a=\overline{a^{(i)}}$ [v. la Note (1)], il se trouvent donc dans la famille des surfaces $S+\overline{S}$ les surfaces qui admettent une déformation infiniment petite du 1-er ordre, la ligne singulière se transforme en une ligne singulière, qui se trouve sur le cylindre $r_1=r_0$, ou bien la ligne singulière se transforme en une ligne plane qui se trouve dans le plan de l'arête circulaire. Ce dernier cas n'a pas lieu si dans le point B se trouve la tangente commune à AB et BC perpendiculaire à Oz. Pour les valeurs $a\neq a^{(i)}$ la surface n'admet aucune déformation.

Considérons la ligne ABC non-symétrique: au point B la tangente à AB n'est pas perpendiculaire à Oz. Soit $r'(0)=a+\theta$, mais la tangente à BC au même point B est perpendiculaire à Oz, $r'(0)=-\infty$.

On sait [v. la Note (3)], que dans ce cas la surface $\overline{S}$ peut se déformer, si $\overline{R}_n(0)=0$. Cette dernière égalité est satisfaite pour $b=b^{(i)}$, $i=1, 2, \ldots m$, où m dépend de n. En prenant $a=\overline{a^{(i)}}$ tel que $Z_n(0)=0$, d'où $R_n(0)\neq 0$, nous trouvons de (3) la valeur b pour laquelle on a ou bien $\overline{R}_n(0)=0$ (donc les conditions (9) ne seront pas vérifiées) ou bien $b\neq b^{(i)}$, et alors $\overline{S}$ n'admet aucune déformation. La surface $S+\overline{S}$ pour $a=\overline{a}^{(i)}$ ne se déforme pas.

Si nous considérons la famille des lignes ABC à deux paramètres (avec les paramètres a et z_0), dans la famille des surfaces $S+\bar{S}$ se trouvent les surfaces qui admettent la déformation infiniment petite.

2. La recherche par la méthode précédente de la déformation des surfaces de rotation ouvertes à courbure négative avec la ligne circulaire singulière conduit au théorème général: si la ligne singulière est un cercle de latitude ordinaire pour S et $\bar{S}$ et si la ligne frontière ouverte est soumise à la condition que j'ai examinée dans les Notes précédentes, la surface $S+\bar{S}$ pour certaines valeurs de paramètre peut ne pas admettre de déformation, tandis que pour d'autres valeurs la déformation est possible.

Soit la surface $S+\bar{S}$ la même que dans le § 1: $\bar{r}'(0)=-\infty$, $r'(0)=a+\theta$, mais ouverte d'un côté: $\bar{r}(z_1)\neq 0$ et la circonférence de la rotation du point C est ordinaire pour $\bar{S}$. Alors pour $a=\bar{a}^{(i)}$ la surface $S+\bar{S}$ n'est pas déformable, parce que la ligne singulière doit se transformer d'une part en ligne plane dans le plan $z=0$, et d'autre part la ligne singulière peut se transformer seulement en ligne sur le cylindre $r_1=r_0$.

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MATHÉMATIQUES

SUR LE COUPLE DE SURFACES DONT LES ASYMPTOTIQUES DE L'UNE DES SURFACES CORRESPONDENT À UN SYSTÈME CONJUGUÉ DE L'AUTRE ET LES TANGENTES HOMOLOGUES SE COUPENT

Par S. FINIKOFF

(Présenté par S. A. Tchapliguine, de l'Académie, le 1. VII. 1938)

1. Si une correspondance biunivoque est établie entre les points de deux surfaces (M) et (M'), il existe un réseau unique de lignes homologues sur (M) et sur (M') dont les tangentes homologues se coupent. M. Ermolaeff l'appelle le réseau des lignes doubles de la correspondance. Nous le désignerons tout court le réseau d.

Si l'on prend les points M_1, M_2 sur la ligne d'intersection des plans tangents homologues de (M) et (M'), on détermine les deux surfaces par les déplacements projectifs infiniment petits du tétraèdre MM_1M_2M', à savoir:

$$\left.\begin{aligned} dM &= \omega_0^0 M + \omega_0^1 M_1 + \omega_0^2 M_2, \\ dM_1 &= \omega_1^0 M + \omega_1^1 M_1 + \omega_1^2 M_2 + \omega_1^3 M', \\ dM_2 &= \omega_2^0 M + \omega_2^1 M_1 + \omega_2^2 M_2 + \omega_2^3 M', \\ dM' &= \omega_3^1 M_1 + \omega_3^2 M_2 + \omega_3^3 M', \end{aligned}\right\} \quad (1)$$

où le point analytique M_i est l'ensemble de quatre coordonnées homogènes du point géométrique M_i et $\omega_i^k = a_i^k\, du + b_i^k\, dv$.

Le réseau d de (M), (M') est déterminé par l'équation

$$\omega_0^1\, \omega_3^2 - \omega_0^2 \omega_3^1 = 0. \quad (2)$$

La même équation détermine les développables de la congruence (MM'); donc, le réseau d est indéterminé si la correspondance entre les points de (M), (M') est une perspective.

2. Si le réseau coïncide avec le réseau conjugué commun (la base de la correspondance), les deux suites de Laplace construites relativement à ce réseau à partir de l'une surface ou de l'autre, sont inscrites dans la suite (MM') et circonscrites à la suite (M_1M_2).

Dans une Note [1] récente j'ai examiné le réseau d composé des lignes asymptotiques sur les deux surfaces. Je vais examiner la correspondance (M, M') telle que le réseau d sur la surface (M) comprend les asymptotiques et forme sur la surface (M') un système conjugué.

3. Si l'on prend le réseau d comme lignes coordonnées u, v et les points d'intersection des tangentes homologues comme points M_1, M_2,

la normalisation convenable des points analytiques M, M_1, M_2, M' réduit le tableau des composants a_i^k, b_i^k à la forme:

$$\begin{array}{|cccc|}
\frac{a-m}{2} & 1 & 0 & 0 \\
a_1^0 & \frac{m-a}{2} & \beta & 0 \\
0 & n & \frac{a+m}{2} & 1 \\
0 & a_3^1 & 0 & -\frac{a+m}{2}
\end{array}
\qquad
\begin{array}{|cccc|}
\frac{b-n}{2} & 0 & 1 & 0 \\
0 & \frac{b+n}{2} & m & 1 \\
b_2^0 & \gamma & \frac{n-b}{2} & 0 \\
0 & 0 & b_3^2 & -\frac{b+n}{2}
\end{array} \qquad (3)$$

où i est le numéro de la ligne, k — celui de la colonne. Quelle que soit une surface donnée (M), on peut lui attacher avec quatre fonctions arbitraires d'un argument une surface (M') qui répond aux conditions posées.

Si $a_3^1 = b_3^2$, la liaison entre les surfaces (M), (M') est réciproque: les tangentes asymptotiques de (M') coupent les tangentes des lignes du réseau conjugué homologue de (M). Pour une surface arbitraire (M) la surface (M') en question sera déterminée avec deux fonctions arbitraires d'un seul argument. Le réseau d est indéterminé, les deux surfaces sont en correspondance de perspective.

4. En revenant au cas général il faut noter que la congruence (MM') est toujours conjuguée aux asymptotiques de (M), c'est-à-dire les développables correspondent aux asymptotiques de (M), donc, les plans focaux passent par les tangentes asymptotiques de (M). Les foyers de $(M_1\ M_2)$ les divisent harmoniquement.

Inversement, à chaque surface (M) on peut attribuer avec deux fonctions arbitraires d'un seul argument des congruences (MM') conjuguées à ses asymptotiques; chaque congruence porte sur ses rayons les points homologues d'une famille de surfaces (M'), dépendant de deux fonctions d'un seul argument et telles que le réseau d de la correspondance ponctuelle établie par les rayons de la congruence entre (M) et (M') est conjugué sur (M') et contient les asymptotiques de (M).

5. Les points d'intersection des tangentes homologues sont les transformées de Laplace de la surface (M') relativement au réseau d, si $m=0$, $n=0$. Les rayons MM', M_1M_2 sons conjugués par rapport aux quadriques de Darboux attachées au point M de la surface (M). Le réseau d sur (M') est harmonique, les transformées de Laplace des tangentes du réseau $M'M_1$, $M'M_2$ sont situées dans le plan tangent de (M), donc se coupent. Les transformées de Laplace du second ordre du point M', c'est-à-dire les foyers M_{22}, M_{11} des rayons M_1M_{1u}, M_2M_{2v}, sont situées respectivement sur les tangentes asymptotiques MM_2, MM_1. La surface (M) n'est pas arbitraire, elle appartient à une classe spéciale dépendant de 6 fonctions arbitraires d'un seul argument.

Il est évident que la surface (M') peut être associée avec une seule surface (M) qui est l'enveloppe des plans contenants les transformées de Laplace des tangentes $M'M'_u$, $M'M'_v$. Inversement, une surface (M) est liée, en général, avec une seule surface (M'), mais il existe une classe particulière dépendant de 4 fonctions arbitraires d'un seul argument dont chaque surface est associée avec deux surfaces M' et M'' dont les tangentes de lignes du réseau u, v coupent les tangentes asymptotiques de (M) respectivement aux points M_1, M_2 et M_{11}, M_{22}. Les six surfaces (M), (M_1), (M_{22}), (M'), (M_{11}), (M_2) composent six nappes focales d'une suite de Laplace périodique à période six. Les asymptotiques de chaque couple de nappes focales opposées de la suite correspondent entre elles.

Deux congruences opposées (M_1M_{22}) et $(M_{11}M_2)$, dont les rayons homologues se coupent, sont projectivement applicables l'une sur l'autre.

6. Une transformation dualistique de l'espace conserve les asymptotiques et les réseaux conjugués, mais change entre eux deux familles de lignes conjuguées. La configuration étudiée de deux surfaces (M) et (M') est transformée, donc, en couple de surfaces $(\overline{M})$ et $(\overline{M'})$ dont les asymptotiques (u, v) de $(\overline{M})$ correspondent à réseau conjugué (u, v) de $(\overline{M'})$, les tangentes homologues se coupant inversement: la tangente u de $(\overline{M})$ coupe la tangente v de $(\overline{M'})$ et vice versa. Les développables de $(\overline{M}_1\ \overline{M}_2)$correspondent aux asymptotiques de $(\overline{M})$, les points M_1, M_2 sont les foyers du rayon $M_1\ M_2$ etc.

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PHYSIQUE

SUR LA COMPOSANTE MOLLE GERBIGÈNE DU RAYONNEMENT COSMIQUE

Par N. S. IVANOVA

(Présenté par S. I. Wawilow, de l'Académie, le 1.VIII.1938)

Les travaux récents (Rossi, Auger) ont révélé l'existence de deux composantes du rayonnement cosmique—composante molle (M) et composante dure (D), de nature toute différente.

Il est établi à présent que le groupe mou est constitué par les électrons et photons de haute énergie. Il est admis généralement que les propriétés de ces particules sont quantitativement décrites par la théorie de Bethe-Heitler et la théorie des gerbes (production de paires en cascades) qui en est la conséquence. La vérification de cette dernière théorie [1] est un problème actuel de grande importance. L'étude de la courbe de Rossi peut servir à cette vérification.

L'interprétation de ladite courbe est cependant compliquée par le fait qu'on a affaire avec une superposition des gerbes d'origines différentes provenant d'une part du groupe M et de la composante dure de l'autre. Nous avons essayé de séparer les deux effets en utilisant la méthode suivante.

Deux séries d'observations etaient effectuées avec le même dispositif des compteurs montés en coïncidences, enregistrant les gerbes: d'abord sans aucun écran et ensuite avec un écran de plomb (de 6 à 9.2 cm) situé au-dessus des compteurs à une distance de 60 cm environ (fig. 1). L'écran était suffisant pour absorber totalement la portion molle dans un angle solide de $35\times45°$ environ. [Dans ce qui suit nous convenons de nommer groupe mou la fraction du rayonnement cosmique (observé dans l'air au niveau de la mer) qui est absorbée dans 6 cm de plomb. Dans une Note suivante seront discutées les questions concernant la relation entre les deux groupes (M et D)]. En désignant par A le nombre de coïncidences par heure observées sans écran et par B le même nombre avec écran, nous aurons des équations symboliques suivantes:

$$A = M(<40°)+D(<40°)+(M+D)(>40°),$$
$$B = D(<40°)+(M+D)(>40°).$$

En retranchant pour chaque épaisseur de l'écran gerbigène (placé immédiatement au-dessus des compteurs) la seconde valeur (B) de la première (A), nous trouvons séparément le nombre de gerbes (de coïncidences) pour le raynnement mou dans un certain angle solide formé par l'écran

$$A-B = M(<40°).$$

Fig. 2 présente les courbes obtenues en utilisant le procédé indiqué. La courbe I correspond à l'écran composé successivement par des couches de plomb—1.5 cm (immédiatement au-dessus des compteurs), d'aluminium (jusqu'à 40 cm) et encore de plomb.

La courbe *II* correspond de même à l'écran composé de couches d'aluminium (immédiatement au-desssus des compteurs)+plomb.

Il faut, bien entendu, tenir compte des impulsions parasitaires qui ne sont pas inclues dans les équations précédentes et qui proviennent des gerbes prenant naissance dans le plafond de la pièce de travail*, dans l'écran de plomb ou dans le support du dispositif détecteur etc. L'intersection des courbes de fig. 2 avec l'axe des ordonnées indique la différence des nombres de coïncidences parasitaires observées avec l'écran (9.2 cm de plomb) et en absence de cet écran.

Il est possible de tirer de ces courbes de différentes conclusions permettant la vérification de la théorie de formation des gerbes (par des processus de création de paires en cascades).

I. D'après cette théorie il fallait s'attendre à ce que l'on put représenter les observations relatives à des écrans mixtes par une courbe continue si l'on exprime les épaisseurs des couches de différentes substances, dont l'écran est composé, en utilisant comme unité de longueur une unité spéciale t**.

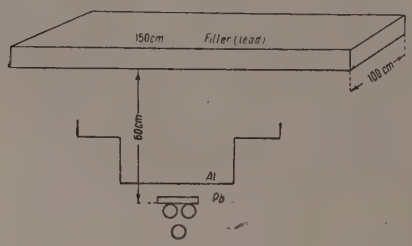

Fig. 1.

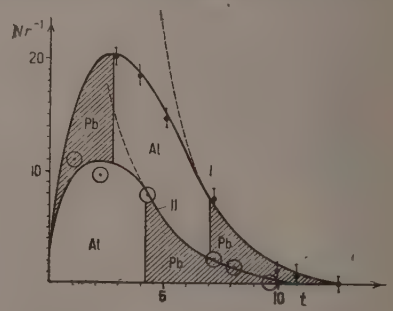

Fig. 2.

L'épaisseur optimale de différents écrans exprimée en unités spéciales doit être la même.

On adopte ces unités de longueur pour porter les points expérimentaux sur les graphiques. On voit bien que les données expérimentales peuvent être représentées par des courbes continues. Il est possible de tracer ces courbes (comme le montre fig. 2) de manière que le maximum soit situé aux environs de la même épaisseur à 2—3 unités près, dans le cas de plomb ainsi que d'aluminium***.

II. D'après la théorie le coefficient d'absorption du rayonnement gerbigène doit être très grand. En tant que «l'effet de transition» est éliminé, le rayonnement gerbigène subit une décroissance exponentielle avec un coefficient d'absorption dont la valeur (la même pour tous absorbants en t-unités) est égale a 1.5 cm^{-1} environ dans le cas de plomb.

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* Les observations ont été effectuées dans le laboratoire situé dans le plus haut étage de l'Institut Physico-Technique de Leningrad.

** Cette unité de longueur est définie par l'expression suivante:

$$[t] = \left[\frac{4}{137}\left(\frac{e^2}{mc^2}\right)^2 N\bar{Z}\lg 183 Z^{-\frac{1}{3}}\right]^{-1},$$

où N est le nombre d'atome par unité de volume. Par exemple $[t] = 0.52$ cm de plomb et $[t] = 9.2$ cm d'aluminium.

*** La limite de pénétration des rayons mous comme le montrent les courbes de la fig. 2 correspond a 12 t-unités. Ce résultat s'accorde bien avec les courbes de Rossi obtenues par P. Auger [2] et Morgan et Nielsen [3] qui ont éffectué les observations avec des écrans de plomb de grande épaisseur. Cela veut dire que 40 cm Al=4.35 t-unités (qui faisaient partie d'écran mixte que nous avons utilisé) sont bien équivalents à 2. 25 cm Pb=4.35 t-unités. (Le même résultat, que nous exposerons dans une publication plus détaillée, ressort aussi de nos observations avec l'écran de plomb.)

La condition mentionnée, à savoir l'élimination des effets de transition, doit être réalisée approximativement pour les parties extrêmes, les tailles des courbes de fig. 2.

En fait, la fig. 2 pour les intervaux correspondants ($t>4$ dans le cas de la courbe *II* et $t>6$ en cas de la courbe *I*) montre une décroissance exponentielle (avec le même coefficient d'absorption). On voit que les courbes expérimentales se confondent avec des courbes exponentielles (dont les parties situées dans la région de t inférieure à des limites indiquées ci-dessus sont tracées en pointillés). D'après la fig. 2 on a les mêmes courbes exponentielles dans le cas des deux écrans, déplacée l'une contre l'autre. Ceci est tout naturel car l'introduction d'une plaque de plomb (1.5 cm) entre l'aluminium et les compteurs (courbe *I*) conduit à l'augmentation de la «sensibilité» des compteurs. Pour les mêmes t on observe donc une intensité I_{Pb} supérieure à celle I_{Al}, que l'on trouve dans le cas d'aluminium sans la plaque de plomb, dont il a été question.

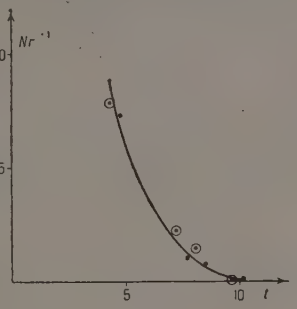

Fig. 3.

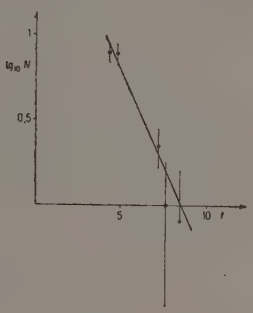

Fig. 4.

En comparant les deux courbes on peut évaluer la relation $\frac{I_{Pb}}{I_{Al}}$. Cette relation est égale à $\frac{I_{Pb}}{I_{Al}}=3.6$.

Avec le caractère exponentiel des deux courbes s'accorde bien le fait que les limites pratiques de pénétration des rayons mous sont différentes dans les deux cas envisagés, à savoir, respectivement $t=11$ et $t=13$ unités.

En déplaçant la courbe *I* (de 2.5 unités parallèlement à l'axe des abscisses) on peut la faire coïncider avec la courbe *II* ce que montrent, à l'échelle logarithmique, les fig. 3 et 4.

Les courbes des fig. 3 et 4 sont les courbes exponentielles avec un coefficient d'absorption $\mu=0.52\ t^{-1}$.

On voit que conformément aux déductions de la théorie le coefficient d'absorption des particules gerbigènes est très élevé:

$$\mu=1\pm0.15\ \text{cm}^{-1}\ \text{de plomb.}$$

Il surpasse sensiblement la valeur qu'on attribue à la composante molle tirée d'analyse de la courbe d'ionisation dans l'atmosphère et s'approche de la valeur limite qui résulte de la théorie Bethe-Heitler pour les particules «légères» de très haute énergie.

Si l'on suppose que le rayonnement gerbigène envisagé est dû aux électrons (ou photons) primaires qui produisent des gerbes dans l'atmosphère par processus en cascade, on peut, en se basant sur la théorie et sur la valeur du coefficient d'absorption, en tirer la valeur de l'énergie moyenne de ces particules p r i m a i r e s.

En omettant les détails du calcul nous en donnons le résultat. L'énergie des particules primaires (légères) que l'on peut supposer responsables de la fraction molle du rayonnement cosmique observé au niveau de la mer, d'après le calcul est de l'ordre de 10^{11}—10^{12} eV. Or, d'aprés Heitler (4), on déduit de l'étude de la courbe d'absorption dans l'atmosphère et de l'effet géomagnétique pour la même grandeur, la valeur de l'ordre de 10^{13}—10^{14} eV.

Cette divergence prouve que l'hypothèse concernant l'origine de la composante molle n'est pas exacte.

La supposition que le rayonnement gerbigène présente une composante indépendante du groupe dur, conduit à une contradiction encore plus grave, si l'on tient compte de la relation $\frac{I_{Pb}}{I_{Al}}$ qui résulte des courbes de la fig. 2.

Le rapport $\frac{I_{Pb}}{I_{Al}}$ pour le maximum des deux courbes est égal à $\frac{I_{Pb}}{I_{Al}}=2-3$ (les deux limites indiquées correspondent à des suppositions différentes possibles concernant la valeur du zéro). Vers la fin des courbes ce rapport, comme nous l'avons montré, est $\frac{I_{Pb}}{I_{Al}}=3.6$.

Les résultats analogues ont été trouvés par d'autres observateurs.

III. Cependant d'après la théorie des gerbes il fallait s'attendre à une valeur de l'ordre de 15 ou plus.

Cela résulte de la loi de la distribution des particules constituantes des gerbes. D'après la théorie la fonction de distribution $N(E)$ se présente ainsi:

$$N(E)=\text{const}, \qquad \text{si } E<\varepsilon,$$

où ε est l'énergie critique, et

$$N(E)=N(\varepsilon)\left(\frac{\varepsilon}{E}\right)^{s-1}, \quad \text{si } E>\varepsilon.$$

En cas de l'air $\varepsilon\approx 100$ mV, s est un paramètre déterminé par la valeur du coefficient d'absorption $\mu=\lambda(s)$ des particules formant la gerbe [1].

En particulier, la valeur $\mu=0.5\ t^{-1}$ trouvée plus haut donne pour s la valeur $s=1.9$.

En admettant que t o u t e s les gerbes composées au moins de t r o i s particules ionisantes* (c'est-à-dire six particules en total) sont enregistrées, il se trouve que les particules gerbigènes efficaces sont: en cas de l'écran de plomb—tous les électrons et les photons dont l'énergie $E>E_{min}=6\varepsilon_{Pb}=$ $=60$mV et dans le cas d'aluminium—toutes les particules avec une énergie $E>E_{min}=6\varepsilon_{Al}=360$ mV.

Le nombre de particules en question est déterminé dans les deux cas par la surface délimitée par la courbe $N(E)$ (relative à l'air).

On voit aisément que la relation des surfaces correspondantes est égale à $\frac{S_{E>360}}{S_{E>60}} \approx 15$ en cas où $s=1.9$.

De là il est à prévoir pour la relation $\frac{I_{Pb}}{I_{Al}}$ une valeur de l'ordre de 15 ou plus. Ceci est en désaccord frappant avec le rapport trouvé expérimentalement.

Il est possible de supprimer la divergence envisagée si l'on suppose que le rayonnement gerbigène mou observé au niveau de la mer est en majeure partie d'origine secondaire en état d'équilibre avec la fraction dure. Dans la Note suivante nous exposerons quelques preuves immédiates de cette hypothèse.

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Leningrad.

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LITTÉRATURE CITÉE

[1] Proc. Roy. Soc., **166**, 213 (1938). [2] Journ. d. Phys., VII, 58 (1936). [3] Phys. Rev., **52**, 564 (1937). [4] Proc. Roy. Soc., **161**, 261 (1937).

* En réalité la probabilité qu'une gerbe sera enregistrée s'approche à l'unité en cas seulement où le nombre de particules ionisantes est beaucoup plus grand que 3. De là le rapport $\frac{I_{Pb}}{I_{Al}}$ devait être encore plus grand d'après le calcul.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
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PHYSIQUE

SUR LA COMPOSANTE DURE DU RAYONNEMENT COSMIQUE ET LA COURBE DE ROSSI

Par N. S. IVANOVA

(Présenté par S. I. Wawilow, de l'Académie, le 1.VIII.1938)

L'étude du groupe dur du rayonnement cosmique composé par des électrons lourds est actuellement d'une importance première. En particulier, la question de l'origine des gerbes produites par les rayons durs présente un grand intérêt. Il est évident qu'en majeure partie ces gerbes sont d'origine tertiaire et qu'elles résultent des processus de production des paires en cascades provoquées par des électrons secondaires expulsés par les particules du groupe pénétrant. Cependant le mécanisme des processus qui sont responsables de l'apparition des électrons gerbigènes secondaires n'est pas encore élucidé. Il est certain que les rayons δ jouent un rôle important. Il faut aussi s'attendre à quelques processus nucléaires (1).

D'après P. Auger et d'autres, les gerbes accompagnant le groupe pénétrant, observées aux grandes profondeurs, sont caractérisées par une courbe de Rossi, représentée schématiquement sur la fig. 1, *B*, qui diffère sensiblement de la courbe (fig. 1, *C*) observée dans les conditions usuelles.

En ce qui concerne cette dernière courbe, on l'interprète d'habitude comme la somme de deux courbes (*A* et *B*, fig. 1) dont la première est attribuée à la composante molle, qui est indépendante de la portion dure et qui est produite par des électrons légers et photons pénétrants dans l'atmosphère de l'espace cosmique. Il est admis qu'à une certaine profondeur (supérieure à 5—10 m d'eau au-dessous du niveau de la mer) cette composante est totalement absorbée, de sorte qu'il ne reste plus que la seconde composante, la courbe *B* de fig. 1. Il est à rappeler que l'interprétation envisagée fut suggérée récemment et qu'auparavant un autre schéma a été adopté: on attribuait la composante molle qui est responsable de la «bosse» de la courbe de Rossi (*C*) au rayonnement secondaire.

En ce qui concerne l'allure de la courbe de Rossi, les deux interprétations conduisent au même résultat si, dans le cas de la deuxième hypothèse, on admet que l'intensité du groupe mou en équilibre dans les milieux légers est sensiblement plus importante que dans les absorbants lourds. En effet si dans le cas de plomb cette intensité est pratiquement nulle, les deux suppositions conduiraient au même résultat pour le passage «air—plomb».

Il est à noter que, contrairement à l'opinion généralement admise, d'après la théorie des gerbes il fallait s'attendre à ce que la courbe de Rossi, dont la fraction dure est caractérisée, soit de la forme *C* (et non de *B*), c'est-à-dire que les conditions de la deuxième supposition envisagée tout à l'heure aient lieu.

En effet, si les électrons secondaires de très haute énergie* sont produits dans l'air, le rayonnement électronique en état d'équilibre qui se produira par la suite des processus de cascades, aura une énergie moyenne de l'ordre de l'énergie critique, c'est-à-dire de l'ordre de $\varepsilon_{Air} = 100\,\text{mV}$. Lors du pas-

* De tels électrons seront créés par la suite de la production des rayons δ.

sage dans le plomb ce rayonnement provoquera des gerbes en tant que $\varepsilon_{PB} = 10$ mV. ce qui voudra dire qu'on a affaire à un rayonnement secondaire gerbigène. Le même rayonnement en équilibre dans le plomb ne pourra pas, en agissant sur l'écran de plomb, produire des gerbes nouvelles, car son énergie moyenne est de l'ordre de 10 mV. Il est possible d'établir immédiatement par l'expérience suivante l'origine du groupe mou observé au niveau de la mer.

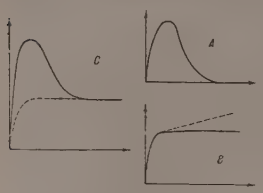

Fig. 1.

On peut supprimer la composante molle faisant partie du rayonnement cosmique dans l'air par un filtre de plomb d'une épaisseur convenable. D'après nos expériences 6 cm de plomb sont pratiquement suffisants*.

En interposant entre le filtre et l'écran (1.5 cm de plomb) immédiatement au-dessus des compteurs [6] des couches d'un absorbant léger, d'aluminium par exemple, on devrait observer une régénération des rayons mous, si les conditions de la seconde supposition ont lieu, de sorte que par suite d'introduction de l'aluminium le nombre de coïncidences par heure serait sensiblement augmenté, tandis que si la première hypothèse est exacte une telle augmentation n'aurait pas lieu.

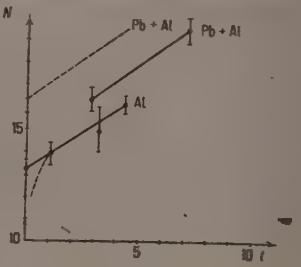

Fig. 2.

Nous disposions de quantités suffisantes de plomb ($\sim$1500 kg) et d'aluminium ($\sim$600 kg) pour effectuer de pareilles observations. La courbe *II* (Pb+Al) de la fig. 2 en montre le résultat.

Sur l'axe des abscisses est portée l'épaisseur d'aluminium exprimée en *t*-unités. Immédiatement au-dessus des compteurs se trouvait un écran de plomb (1.5 cm), à une distance de 60 cm un filtre de plomb de 9.2 cm d'épaisseur (*I*, fig. 1). Comme on voit, l'introduction des couches d'aluminium (jusqu' à 40 cm) entre le filtre et l'écran de plomb provoque une augmentation bien nette du nombre des coïncidences observées**.

Une appréciation quantitative directe de l'effet envisagé est à peine possible étant donné que le filtre supprime une partie seulement, quoique prépondérante du rayonnement mou (dans un certain angle solide) et que, en plus, le «fond» des coïncidences parasitaires provenants du filtre même n'est pas connu. Cependant les conclusions suffisamment définitives peuvent être tirées des courbes de la fig. 3. La courbe *I* de la fig. 3 montre la variation du nombre de coïncidences qu'on observe lorsqu'on augmente l'épaisseur de l'écran de plomb qui se trouve, cette fois aussi, sous le même filtre de plomb (9.2 cm).

Un changement de sensibilité (efficacité) des compteurs nécessitait une réduction des données obtenues au cours des séries précédentes. La courbe *II* (fig. 3) n'est que l'ancienne courbe (1.5 cm Pb+Al) après cette réduction.

On voit qu'en cas de radiation filtrée l'interposition des couches d'aluminium au-dessus de l'écran de plomb (1.5 cm) augmente le nombre de coïncidences tandis que l'introduction du plomb dans les mêmes conditions diminue ce nombre (la partie initiale de la courbe *I* de la fig. 3).

* D'après nos observations [6] l'augmentation de l'épaisseur du filtre de 6 à 9.2 cm de plomb ne change pas le nombre de coïncidences par heure.

** Au surplus des observations décrites ici, la même augmentation a été constatée au cours des deux séries comportant une statistique considérable (avec 1.5 cm de plomb couvrant les compteurs et sans plomb) et les mêmes compteurs disposés en triangle dont le sommet était dirigé vers le haut.

On peut affirmer, que les particules pénétrantes elles-mêmes, ainsi qu'un rayonnement secondaire en état de l'équilibre avec le groupe pénétrant dans le plomb, ne peuvent produire dans un écran de plomb que des gerbes dont le nombre accroît avec l'épaisseur de l'écran ou, s'il diminue, alors tout à fait insensiblement—avec l'intensité primaire. Par conséquent la chute observée dans la région 1.5—6 cm de plomb (fig. 3) caractéristique pour la courbe usuelle de Rossi, ne peut être dûe qu'aux rayons moux obliques incidents en dehors de l'angle solide (35—45°) couvert du filtre.

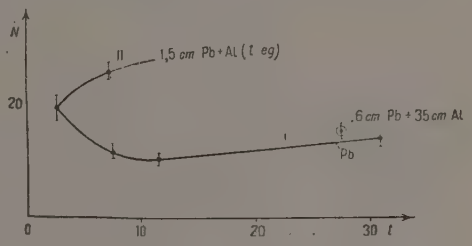

Fig. 3.

Dans le cas de la courbe *II* (fig. 3) ce dernier rayonnement incident sur le même écran de plomb (1.5 cm) est absorbé dans l'aluminium pour le même t (l'axe des abscisses) en même proportion que dans le plomb. Cependant dans ce dernier cas le minimum n'a pas lieu et l'on observe dès le début une croissance de nombre des gerbes. On en conclut, que la composante dure crée dans l'aluminium des particules gerbigènes qui, en agissant sur l'écran de plomb au-dessous d'aluminium, donnent naissance aux gerbes et composent l'absorption de la portion molle incidente en dehors de l'angle solide formé par le filtre. Le minimum de la courbe *I* a lieu vers 10—12, c'est-à-dire vers une épaisseur qui est suffisante pour absorber tous les rayons mous [6].

Comme le montre la fig. 3, pour la même épaisseur d'aluminium (en t-unités) qui est aussi suffisante pour absorber tous les rayons mous, on observe environ 8 coïncid./heure supplémentaires au surplus de celles qui sont observées sous l'écran de plomb (sans l'aluminium). D'après ce qui précède il faut attribuer ces 8 coïncid./heure aux électrons (ou photons) secondaires excités par le groupe dur dans l'aluminium.

Selon les données de notre Note précédente [6] le nombre des coïncidences par heure dû à la composante molle dans le même angle solide ne surpasse pas 24 par heure (après la réduction à la nouvelle sensibilité). Cela veut dire, que l'intensité du rayonnement gerbigène secondaire produit dans l'aluminium est dans tous les cas comparable à celle du groupe mou dans l'air. Le rayonnement gerbigène secondaire prenant naissance dans l'air doit être plus efficace que celui produit dans l'aluminium en tant que l'énergie critique en cas de l'air est deux fois plus grande que dans l'aluminium. En surplus les électrons secondaires produits simultanément dans l'aluminium (constituant une gerbe) provoqueront dans la plupart des cas une seule impulsion, tandis qu'en cas où ces électrons sont formés dans l'air, généralement à une grande distance des compteurs, il seront enregistrés séparément.

1. De tous ce que nous venons d'exposer il est à conclure que contrairement aux conceptions généralement admises la courbe de Rossi (fig. 1, *C*) est, dans une partie notable toutefois, dûe à l'effet de transition de la composante dure, c'est-à-dire qu'une partie notable au moins du groupe mou est d'origine secondaire*. L'accroissement de la courbe *I* nettement visible dans la région $t > 11$ correspond au second maximum de la courbe de Rossi. Le point «6 cm Pb+35 cm Al» est porté vers $t = 24.3$ (l'épaisseur du plomb équivalent en masse superficielle au 35 cm d'aluminium etait calculé d'abord et cette épaisseur portée ensuite en t-unités).

* Sans tenir compte des indications indirectes, ils existent actuellement, paraît-il, des preuves immédiates de cette conclusion[5].

Considérons la courbe (Al) de la fig. 2. Cette courbe met en évidence, que le nombre de gerbes excitées par la composante dure dans l'aluminium s'accroît jusqu'aux épaisseurs assez considérables de l'écran (40 cm Al). L'allure initiale de la courbe reste incertaine le «fond» parasitaire déterminant l'ordonnée initiale étant inconnu. Il en résulte l'affirmation suivante.

2. En cas des gerbes produites par la composante dure dans les éléments légers on a besoin des épaisseurs très considérables ($> 100 \frac{g}{cm^2}$) pour l'établissement de l'état de saturation*, de sorte que la courbe Rossi soit caractérisée par la forme schématiquement indiquée sur la fig. 1, *B* en pointillés. Cette forme de la courbe ne contredit pas aux déductions de la théorie des gerbes en révélant cependant l'existence des électrons (ou de photons) de très haute énergie (surpassant 300 mV) produits par les particules pénétrantes.

Que la pente en question doit être attribuée aux électrons (ou photons) secondaires et non aux particules semi-lourdes, ressort du fait que l'introduction de 1.5 cm de plomb au-dessous d'aluminium provoque une augmentation du nombre des coïncidences [la courbe se déplace en haut, comme on le voit sur la fig. 2, la courbe (Pb+Al) tracée en pointillés]**.

La comparaison des courbes de la fig. 2 et de la fig. 3 donne à croire que le nombre des gerbes excitées par la composante dure est sensiblement plus grand dans le cas des matériaux légers qu'en cas des matériaux lourds***.

Faute de place, nous laissons de côté toute analyse de cette question. Remarquons seulement qu'il ressort de la théorie de formation des paires en cascades que le nombre des gerbes produites par les rayons δ (en cas où l'énergie maxima de ces derniers est très élevée) est indépendant de Z (ou s'accroît même quelque peu avec Z). La particularité que nous venons d'exposer veut dire que les électrons secondaires de très haute énergie**** sont produits par des procédés que nous ignorons et qui sont caractérisés par la croissance de la section efficace au plus, proportionellement à la première puissance du nombre atomique.

Les résultats exposés dans les § 1 et 2 contredisent aux données des observations souterraines. Cependant, l'étude de la courbe de Rossi dans les conditions de ces observations est gênée par la difficulté d'éliminer le «fond» général des coïncidences parasitaires qui est dans ce cas-là très considérable. Deux observateurs, P. Auger et Pickering [4], en se basant sur ces observations souterraines, ont d'abord faussement conclu qu'il n'existe aucune gerbe accompagnant la composante dure.

L'étude dont les résultats sont exposés dans le présent article a été faite dans le laboratoire de M. Skobelzyn.

Institut Physico-Technique.
Leningrad.

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* Les résultats analogues (avec un dispositif quelque peu différent) ont récemment obtenu Bothe et Schmeiser [2]. Nous ne pouvons cependant nous allier à l'interprétation suggérée par ces auteurs, qui attribuent cet effet aux particules secondaires pénétrantes. En comparant les courbes *I* et *II* de la fig. 3 il faut conclure d'une façon définitive que le rayonnement secondaire qui cause la pente de la courbe (Al) de la fig. 2 est un rayonnement mou.

** La ligne Pb+Al en pointillés est la courbe Pb+Al déplacée à gauche parallèlement à l'axe des abscisses de 2.9 t-unités (l'épaisseur du plomb).

*** Ce résultat semble en accord avec les observations de Morgan et Nielsen [3].

**** Qui est grande par rapport à l'énergie critique des éléments légers.

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PHYSICS

ON THE LIQUEFACTION OF HELIUM BY MEANS OF THE JOULE-THOMSON EFFECT

By J. L. ZELMANOV

(Communicated by A. F. Joffe, Member of the Academy, 1.VII.1938)

In a preceding paper (1) the author put forth the hypothesis that the limiting factor in the liquefaction of helium with the help of the Joule-Thomson effect lies often in the impossibility of heat exchange, connected with the shape of the curves of equal enthalpy in the region of the T—S diagram, bordering the boundary curve of the liquid.

In order to check the correctness of the assumption and to estimate its value it is enough to know the enthalpies at one temperature, namely the normal boiling temperature of helium. It is easy to calculate these values from data referring to some other functions of state in the region under investigation.

If the pressure p and the temperature T are chosen as independent variables then we have, as well known

$$\left(\frac{\partial i}{\partial p}\right)_T = \frac{1}{\rho} + \frac{T}{\rho^2}\left(\frac{\partial \rho}{\partial T}\right)_p,$$

or if the enthalpy i is measured in cal/kg, the pressure in atmospheres and the density ρ in g/cm³,

$$\left(\frac{\partial i}{\partial p}\right)_T = 0.0242\left[\frac{1}{\rho} + \frac{T}{\rho^2}\left(\frac{\partial \rho}{\partial T}\right)_p\right].$$

We find the data of p, T, ρ and $\left(\frac{d\rho}{dT}\right)_p$, which is necessary for carrying out the calculation, in the paper by Keesom and Miss. Keesom (2).

In Table 1 values taken from Keesom and Miss. Keesom and those calculated are given:

Table 1

p	ρ	$-\left(\frac{\partial \rho}{\partial T}\right)_p$	$\left(\frac{\partial i}{\partial p}\right)_T$	
1	0.1252	0.0222	0.049	
5	0.1399	0.0122	0.110	
10	0.1502	0.0073	0.128	T=const=4.2° K
15	0.1575	0.0058	0.130	
20	0.1634	0.0050	0.129	
25	0.1682	0.0045	0.128	
30	0.1724	0.0040	0.127	

In order to calculate the enthalpies, $\left(\frac{di}{dp}\right)_T$ was represented graphically as a function of the pressure (Fig. 1) and the curve obtained was integrated approximately by the method of trapeziums (Fig. 2). The enthalpy of the liquid at $T=4.2°$ K and $p=1$ atm. was assumed to be equal to zero.

The limiting liquefaction coefficients for a simple liqurfier which consists of a heat-exchanger and of one throttling-valve, where the Joule-Thom-

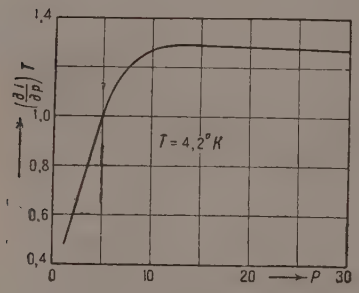

Fig. 1.

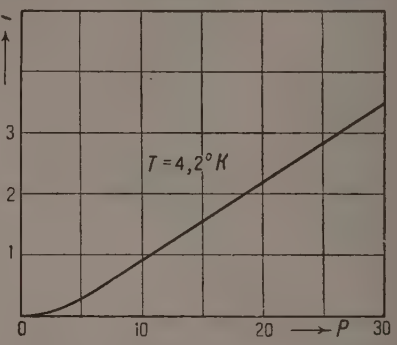

Fig. 2.

son effect takes place, under ideal conditions of heat exchange can easily be determined from the equation

$$\eta = 1 - \frac{i}{r},$$

where η denotes the liquefaction coefficient, r —the evaporation heat and i—the enthalpy of the compressed gas in the boiling point. The equation means that the temperature of the compressed gas in the heat-exchanger cannot sink below the boiling point of the liquid. Putting $r=4.9$ cal/kg we obtain the boundary values given in the second column of Table 2.

Table 2

p	η_{id}	η_{pr}
10	0.81	~0.7
15	0.68	~0.6
20	0.55	~0.4
25	0.42	~0.3
30	0.29	~0.2

In order to make the heat exchange possible it is necessary to have a temperature difference of the order of 0.5°, the limiting liquefaction coefficients are thereby somewhat decreased and values are obtained which are given in the third column of Table 2.

The results obtained satisfactorily agree with the liquefaction coefficients obtained in practice.

1. On the basis of the data of Keesom and Miss. Keesom (²) the enthalpies of helium at $T=4.2°$ K for the pressure interval 1—30 atm. are calculated.

2. The limiting liquefaction coefficients are calculated as a function of the initial pressure for a simple liquefier, consisting of a heat-exchanger and a throttling-valve.

3. The results obtained agree well with experimental data and confirm the assumption about the limiting liquefaction coefficients, which was formulated in the preceding paper.

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PHYSIQUE

MESURE DE L'ABSORPTION DES ONDES ULTRA-SONORES DANS L'AIR ET DANS L'ARGON

Par A. T. DADAIAN et E. J. PUMPER

(Présenté par L. I. Mandelstam, de l'Académie, le 28. VI. 1938)

Introduction. Si l'on détermine les grandeurs de la viscosité et de la conductibilité de la chaleur selon Stokes et Kirchhoff en cas d'une onde plane, on trouve pour le coefficient d'absorption du son l'expression suivante (1):

$$\alpha_s = \frac{\omega^2}{p}\,\frac{1}{2a\gamma}\left[\frac{4}{3}\eta + \frac{\gamma-1}{C_p}\nu\right], \qquad (1)$$

où ω désigne la pulsation, a — la vitesse de Laplace, $\gamma = \frac{C_p}{C_v}$, p — la pression, η — la viscosité et ν — la conductibilité de la chaleur.

Il existe de plus dans les gaz polyatomiques une absorption supplémentaire du son déterminée par le temps fini d'échange de l'énergie entre les degrés de liberté extérieurs et intérieurs des molécules. Ce fait a été pour la première fois signalé par Kneser (2).

D'après Kneser, le terme supplémentaire dans l'expression du coefficient d'absorption pour les valeurs des fréquences et des pressions qui nous intéressent, si de plus $\tau \ll T$ (où T désigne la période du son et τ — le temps pendant lequel s'établit l'équilibre entre les degrés de liberté extérieurs et intérieurs des molécules), est égal à

$$\alpha_k = C\frac{\omega^2}{p}; \quad \text{où} \quad C = \frac{\tau}{4\pi a}(Q^2-1), \qquad (2)$$

$Q = \frac{a_\infty}{a}$, a_∞ étant la vitesse du son pour $\omega = \infty$ (d'après Kneser). La théorie de Kneser ne peut pas donner de valeur numérique de τ. On peut, toutefois, se proposer la valeur de τ à partir du coefficient d'absorption de Kneser déterminé expérimentalement. Si au cours de l'échange un des degrés intérieurs de liberté prédomine, la vitesse limite a_∞ peut être calculée. La différence des valeurs du coefficient d'absorption α_s obtenue expérimentalement et calculée d'après Stokes permet de trouver α_k. En connaissant α_k et α_s on peut calculer τ pour un gaz donné. Pour les gaz monoatomiques l'absorption doit être donnée par la formule (1). Les valeurs expérimentales du coefficient d'absorption pour l'air, obtenues jusqu'ici par différents auteurs, divergent de beaucoup les unes des autres, ce qui rend impossible la vérification suffisante des considérations théoriques mentionnées.

La série d'expériences décrite dans le présent article a eu pour but de fournir des mesures du coefficient d'absorption dans l'air et dans un gaz monoatomique (argon), pouvant servir de base à la vérification de ces théories.

Méthode de mesure. La méthode de mesure, employée dans nos expériences, a été décrite par L. M. Beliavskaja (3). On place dans l'interféromètre de Pierce (4) un quartz, produisant l'ultra-son. On enregistre, à l'aide d'un indicateur électrique, les réactions sur le quartz de l'onde réfléchie dans l'interféromètre, le réflecteur étant placé d'abord dans le noeud, ensuite dans un ventre du son, puis sans reflécteur. Le coefficient d'absorption est calculé d'après ces données expérimentales.

La valeur de l'amortissement introduite dans le piézo-quartz, alors que le réflecteur se trouve dans le noeud du son, est égale à

$$\vartheta_{max} = \vartheta_\infty \operatorname{ctgh} \alpha l; \tag{3}$$

de même si le réflecteur se trouve dans un ventre, on a

$$\vartheta_{min} = \vartheta_\infty \operatorname{tgh} \alpha l, \tag{4}$$

où ϑ_∞ est l'amortissemeut introduit en l'absence du réflecteur, l étant la distance du réflecteur au quartz.

Il en résulte (à la condition que l'amortissement ϑ que l'ultra-son introduit dans le quartz soit lié avec les données de l'indicateur I par l'expression de la forme $\vartheta = AI + B$) la formule suivante:

$$\operatorname{ctgh} \alpha l = \frac{I_{max} - I_\infty}{I_\infty - I_{min}}, \tag{5}$$

servant à calculer α. Si la mesure s'effectue dans un vase clos (où il est pratiquement difficile de mesurer I_∞), la formule (5) peut être remplacée par l'expression suivante, dérivant aussi de (3) et (4):

$$\cosh \alpha l = \frac{I_{max_2} - I_{min_1}}{2(I_{max_2} - I_{min_1})}, \tag{6}$$

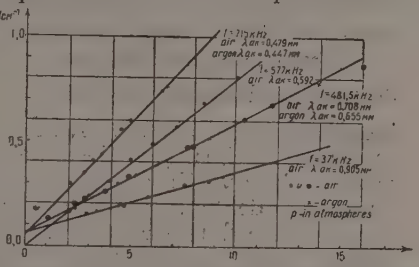
où $I_{max\,1}$ et $I_{min\,1}$ sont des réactions à la distance l du quartz, et $I_{max\,2}$ et $I_{min\,2}$ à la distance $2l$. Il est à souligner, que cette méthode, de même que les méthodes appliquées par d'autres auteurs [(5), (6), (7) et autres] est basée sur l'hypothèse que l'onde acoustique est plane.

Description de l'expérience. Les mesures des coefficients d'absorption étaient généralement éffectuées à l'aide d'un interféromètre métallique de Pierce, où le réflecteur se déplaçait à l'aide d'un micromètre spécial. La surface supérieure (rayonnante) du quartz était argentée et son contact avec l'électrode extérieur de l'interféromètre s'effectuait par un petit ressort plat, dont l'une des extrémités reposait librement sur la surface argentée du quartz. Le piézo-quartz était excité par un circuit oscillateur de Pierce. On intercalait dans le circuit de plaque de l'oscillateur un galvanomètre compensé, d'une sensibilité de l'ordre de 10^{-6}A, servant d'indicateur des réactions du champ acoustique sur le quartz.

Une partie des mesures était effectuée afin de contrôler le fonctionnement du dispositif par l'excitation du quartz par un circuit résonateur. Les résultats des expériences dans les deux cas furent les mêmes. La pression du gaz dans l'interféromètre était enregistrée par un manomètre ordinaire à mercure, de même que par un manomètre de Mac-Leod, dont on se servait pour contrôler la quantité d'air arrivant dans l'interféromètre du dehors. Cette accumulation d'air pendant quelques heures

n'augmentait la pression dans l'interféromètre que de quelques centièmes de millimètre, ce qui est sans importance, vu que la pression minimum au cours des mesures était voisine de 70 mm. On faisait passer l'air par un sécheur à chlorure de calcium. Les mesures étaient effectuées à la température de 16°C.

On portait une attention toute particulière à l'homogénéité du champ acoustique, que l'on contrôlait en comparant les courbes expérimentales des réactions de la colonne acoustique sur le quartz, en fonction de la position du réflecteur, avec les courbes calculées d'après les formules (3) et (4). On choisissait des quartz satisfaisant aux conditions exigées.



Relation du coefficient d'absorption à la pression dans l'air et l'argon.

Les coefficients d'absorption étaient déterminés pour 2 gaz — l'air et l'argon. L'argon avait été choisi comme gaz monoatomique, pour lequel la formule (1) doit être valable. On faisait les mesures de l'absorption sur 4 quartz de fréquences différentes et à différentes pressions du gaz. Les résultats sont donnés sur la fig. 1.

Examen des résultats. Si nous calculons $\alpha\lambda^2$ d'après nos mesures et par la méthode indiquée, nous obtiendrons pour $p = 1$ atm. les valeurs suivantes:

pour l'air	f_{kH}	379	481.5	577	715
	$\alpha\lambda^2_{sm}$	$6.2 \cdot 10^{-4}$	$5.1 \cdot 10^{-4}$	$2.8 \cdot 10^{-4}$	$3.7 \cdot 10^{-4}$;
et pour l'argon	f_{kH}		481.5		715
	$\alpha\lambda^2_{sm}$		$4.7 \cdot 10^{-4}$		$3.2 \cdot 10^{-4}$.

Remarquons de plus que, selon Stokes et Kirchhoff, nous avons pour l'air $\alpha\lambda^2 = 1.65 \cdot 10^{-4}$ et pour l'argon $\alpha\lambda^2 = 1.85 \cdot 10^{-4}$.

La fig. 1 montre qu'au lieu d'obtenir une fonction de la pression de la forme $\alpha = \frac{\kappa}{p}$, on trouve expérimentalement, à l'exception d'une seule fréquence, des fonctions de la forme: $\alpha = \frac{\kappa}{p} + \alpha_0$, où $\alpha_0(p) = \text{const}$.

Si l'on exclut l'influence, sur les résultats, des impuretés du gaz*, on aurait à suspecter la non-homogénéité, comme étant la source des fautes dans le mesurage. Afin d'élucider ce problème les étudiantes de l'université de Moscou E. F. Novikova et F. N. Tsisina ont effectué l'expérience suivante: on installait entre le quartz et le réflecteur un écran, ayant un orifice carré de 1 cm² et pouvant se déplacer parallèlement à la surface du quartz. De plus le contact entre le ressort et la surface argentée s'effectuait en différents points. Il se trouva qu'il était possible d'obtenir d'un seul quartz des valeurs différentes du coefficient d'absorption avec de bonnes courbes de la baisse des réactions. Ceci démontre que la forme des courbes n'est pas un critérium suffisant de l'homogénéité du champ et que la non-homogénéité exerce sur les résultats une influence considérable. Si l'on suppose que l'onde est plane, la loi de la baisse des amplitudes est représentée par l'expression $e^{-\alpha x}$. Alors les formules (3), (4), (5) et (6) sont justes pour une réflexion réitérée. Si l'onde

* Pour déterminer l'influence des impuretés du gaz on y ajoutait spécialement du gaz carbonique en quantité de quelques pourcents, cependant sans aucune influence sur les résultats des mesures. De là on conclut (en tenant compte que la fuite de gaz dans l'appareil est trés petite) que la pureté du gaz était suffisante.

diffère quelque peu de l'onde plane, la réaction sur le quartz peut être écrite sous la forme $A = pf(x, y)\, e^{-\alpha x}$, $f(x, y)$ étant une fonction, caractérisant la configuration du champ, dépendant des phénomènes de diffraction à la surface du quartz et ne dépendant pas de la pression du gaz. Si, pourtant, les lois (3) et (4) sont satisfaites (ce qui a lieu dans nos expériences), on a $f(x, y) \approx B_0 e^{-\alpha_0 x}$, alors $A = pB_0 e^{-(\alpha+\alpha_0)x}$ et, par conséquent, la non-homogénéité du champ intervient dans les mesures comme absorption supplémentaire, dépendant non de la pression, mais seulement de la configuration du champ.

Il est donc tout naturel de proposer l'hypothèse que tous les écarts de la dépendance théorique $\alpha\left(\frac{1}{p}\right)$ (fig. 1) sont conditionnés par la non-homogénéité du champ. Afin d'en éliminer l'influence il convient de tracer les droites par l'origine des coordonnées, parallèlement à elles-mêmes. Pour vérifier cette supposition on altéra artificiellement le champ du quartz, de fréquence 577 kH; ceci donnait (fig. 1) une droite passant par l'origine des coordonnées. Il se trouva qu'alors cette courbe se déplaçait considérablement vers le haut, parallèlement à elle-même. Si l'on introduit d'après ce qui a été dit une correction dans les valeurs d'absorption obtenues (fig. 1), toutes les quatre fréquences donnent dans l'air pour une pression normale les valeurs $\alpha\lambda^2$ de 0.00025 à 0.00028. La valeur théorique d'après (1) est égale à 0.000165. La valeur obtenue par cette methode pour l'argon est 0.00022 au lieu de 0.000185 d'après Stokes.

On pourrait expliquer les données plus grandes par le phénomène de Kneser pour l'air, mais on ne peut faire de telles suppositions pour l'argon. Ceci donne à croire qu'il existe une erreur supplémentaire des mesures de l'ordre de 20% encore non-expliquée.

La petite divergence entre des valeurs d'absorption obtenues par nous et celles de Stokes, pour le cas de l'argon, ainsi que la valeur constante obtenue pour $\alpha\lambda^2$, nous donnent le droit d'envisager tous nos résultats comme étant plus exacts que ceux, obtenus précédemment (les longueurs d'ondes dans l'air et dans l'argon sont presque égales; pour cela il ne doit pas y avoir de grande différence dans les phénomènes de diffraction à la surface du quartz), d'autant plus que les problèmes de l'homogénéité du champ, tout aussi essentiels dans leurs travaux que dans les nôtres, n'ont pas attiré l'attention qui leur est due.

D'autre part, la dépendance linéaire de $\frac{1}{p}$ est mieux observée dans nos résultats, de même que la constance de $\alpha\lambda^2$ (alors que λ^2 est modifiée de 4 fois, $\alpha\lambda^2$ ne l'est que de 10%), ce qui parle de même en leur faveur.

Pendant la période où s'effectuaient les expériences décrites a paru un article de Itterbeck et Märiens [8] où l'on donne les résultats de deux mesures de l'absorption pour l'argon, pour deux pressions et pour la fréquence $\approx 3 \cdot 10^5$Hz. Les valeurs $\alpha\lambda^2$ réduites à une pression normale sont égales d'après ces données à 0.000225 et 0.00018, ce qui à une erreur de mesure près ne diffère pas de nos données.

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PHYSICS

SPECTRAL DISTRIBUTION OF THE ABSORPTION COEFFICIENT IN X-RAYED NaCl CRYSTALS IN CASE OF DISAPPEARANCE OF INNER TENSIONS

By I. KIRVALIDZE

(Communicated by S. I. Wawilow, Member of the Academy, 16.VII. 1938)

It is known that in case of compression deformation in NaCl crystals there takes place a shift of the maximum of the absorption band towards the red end of the spectrum. According to Smekal (1), this shift is accounted for by local elastic tensions of the crystal lattice. If that is the case, then the disappearance of these tensions must be accompanied by a shift of the maximum of the band of absorption towards the short wave end.

One may believe that inner tensions are always present in all kinds of natural crystals, since when a crystal is being cleft out superficial tensions are created which are further transmitted onto the whole crystal. The presence of such tensions is easily detected when a NaCl crystal, bearing a fresh scratch, is examined through a polarization microscope. Fig. 1 shows the picture observed through that microscope. One may clearly distinguish four white small bands, whose presence points to the existence of inner tensions. If the surface of such a crystal is somewhat dissolved, the tensions disappear, which is also easily detected by means of a polarization microscope, since in this case the polarization phenomena disappear too. The object of the present investigation was to show that if a X-rayed NaCl crystal is subjected to superficial dissolution, then simultaneously with the disappearance of inner tensions there should take place a shift of the maximum of the band of absorption towards the short wave end.

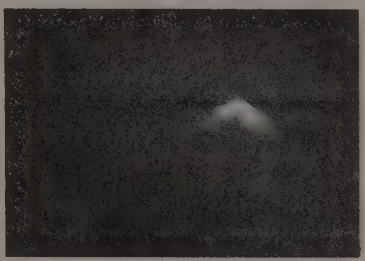

Fig. 1.

The experiment vas conducted in the following way.

NaCl crystals, $1 \times 1 \times 5$ cm large, coloured with X-rays and possessing no noticeable plastical deformations, were chosen, after which we proceeded to measurements of the spectral distribution of the coefficient of absorption. In Fig. 2 (curve *A*) is shown the curve of spectral distribution. The maximum of the absorption band corresponds to the wave-length $\lambda = 463$ mμ. Observed through a polarization microscope such a crystal offers a picture similar

to that shown in Fig. 1. After dissolution the curve for the absorption coefficient has the shape of curve *B*. There may be observed a shift of the maximum absorption band towards the short wave end (maximum at $\lambda = 455$ mμ). After a repeated dissolution no displacement of the maximum is obtained.

However, some of the experiments envolved successive dissolution of very thin layers; each time an increase of the shift of the absorption band was obtained, yet the maximum displacement never exceeded 9—10 mμ.

The described experiments permit of the conclusion that the maximum of the band of absorption usually observed at $\lambda = 460$ mμ has already been shifted towards the long wave end as compared with the maximum $\lambda = 455$mμ.

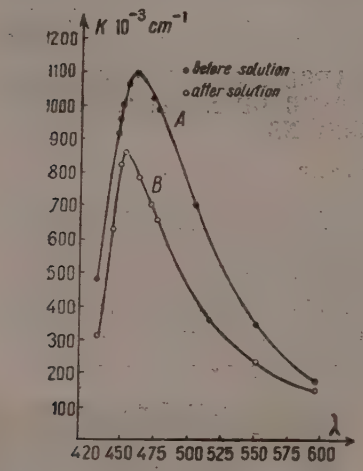

Fig. 2.

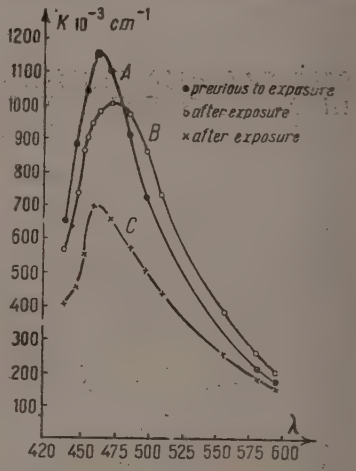

Fig. 3.

It is noteworthy that if a crystal of X-rayed NaCl is previously illuminated by light with a wave-length $\lambda = 465$ mμ, the usual «excitation» of the crystal is obtained, the maximum of the absorption band being shifted towards the long waves (curve *B* in Fig. 3). If such a crystal is next superficiously dissolved, one observes a shift of the maximum towards the short wave end of the spectrum, nearly reaching the point that is attained in the case when excitation is absent.

Hence it may be inferred that the so-called *F'* centrums (according to Paul) are formed in case of a chiefly superficial excitation.

Conclusion

1. It is found that eliminating inner tensions in crystals of X-rayed NaCl a shift of the maximum of the band of absorption towards the short wave end of the spectrum is obtained for about 10 mμ.

2. When the coloured NaCl crystal is illuminated with light with a wave length of 465 mμ, chiefly near the surface of the crystal are created *F'*-centrums, which may be almost totally removed by means of dissolution of thin layers of the crystal.

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PHYSICS

APPLICATION OF TÖPLER'S METHOD TO THE MEASUREMENT OF ULTRA-SOUND ABSORPTION IN AIR

By F. A. KOROLEV

(Communicated by L. I. Mandelstam, Member of the Academy, 7.VII.1938)

Measurements of the absorption of ultra-sound in air and generally in gas have hitherto been effected mostly by means of an ultra-sonnic interferometer (1). This method permits of observing the reaction of the ultra-sonnic column to quartz, and, consequently, to the lamp-generator connected with the latter. The theory of this method is rather complicated. The results obtained by different authors who had used it essentially differ from each other; the introduction of other measuremental procedures would therefore seem highly desirable. In this work an optical procedure of ultra-sound absorption in air is described. This method has already been applied by us both for the investigation of ultra-acoustic field in liquids and for measurements of the absorption of ultra-sound in liquids (2). Töpler's method has been applied also by Rschevkin and Kretschmer (3), Bär (4), Hiedemann (5) and others (6). At the present time its value, simplicity and plainness for the investigation of ultra-sound is commonly acknowledged (7).

Similarly to our previous work (2), in this case too, when studying the absorption of ultra-sound in liquids, the image of the ultra-sonnic field in air, obtained by Töpler's method, without having recourse to stroboscopy, was photographed. Simultaneously a step filter was superimposed upon the image of the ultra-sonnic beam in order to obtain intensitiy marks. Putting the intensity of light dispersed on ultra-sound as proportional to the square of the amplitude of sound, i. e.

$$I \sim A^2,$$

and making allowance for the exponential absorption law

$$A = A_0 e^{-\alpha x},$$

for two points of the ultra-sonnic beam at a distance x from each other, we obtain:

$$\alpha = \frac{1}{2x} \ln \frac{I_0}{I}.$$

In this way we made a great number of photographs, the atmospheric pressure corresponding to densities falling within 930—3600 kHz. The mean results derived from numerous measurements are tabulated below.

These results lead us to the conclusion that the quadratic absorption law is fairly well fulfilled when absorption takes place in the air. The results

Coefficients of Ultra-Sound Absorption in Air

ν—frequency of ultra-sonnic vibrations in kHz	α—absorption coefficient in cm^{-1}	$\alpha\lambda^2 \cdot 10^{-4}$ (λ—length of ultra-sonnic wave in cm)
930	0.18	2.4
2680	1.3	2.1
3520	2.1	2.0
3525	2.3	2.1
3530	2.1	2.0
Mean value .	$\alpha\lambda^2 = 2.1 \cdot 10^{-4}$ cm	

obtained with high frequencies should be considered reliable, since in case of low frequencies takes place a considerable weakening of ultra-sound, due to diffraction. To make the data obtained still more accurate, the author proposes to make analogous measurements for higher pressures and, besides, for other gases too.

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PHYSICS

ON THE ABSORPTION SPECTRUM AND LIFE-TIME OF THE CARBON SULPHIDE RADICAL

By V. KONDRATIEW

(Communicated by N. N. Semenov, Member of the Academy, 8.VI.1938)

In the absorption spectrum obtained for the gas drawn off from a discharge tube filled with sulphur vapour I could notice a series of bands, all graded towards the red. They should be ascribed to the CS radical, as shown by the following table:

$v''v'$	λ_{observ} Å	λ, Å
0 0	2575.3/76.4	2575.6/76.7
0 1	2509.3	2509.5
0 2	2444.9	2444.7
0 3	2385.7	(2386.0)

where the second column contains the wave-lengths for the observed band-heads, while the last column shows the wave-lengths given by Crawford and Shurcliff (1) for CS emission spectrum (system $A^1\Pi—X^1\Sigma$). The close agreement between the two sets leaves no doubt as to their identity. No band corresponding to the band-head (0′′3′) has as yet been recorded in the emission spectrum; the bracketed value in table has been obtained by computation from the Deslandres formula given in the above-cited paper. The two values corresponding to (0′′0′) refer to heads belonging to the *R* and *Q* branch respectively, as shown by Jevons (2) and also by Crawford and Shurcliff (loc. cit). The four absorption bands for CS are seen to fit the series $v''=0\rightarrow v'$ which is characteristic of absorption spectra in general.

In addition to the above four, I further observed two other bands, less intense and also graded towards the red, namely 2505.5 Å and 2587.8 Å (heads). These bands almost coincide with the emission bands 2505.2 Å and 2587.3 Å which, according to Crawford and Shurcliff, are the (0′′0′) and (1′′0′) bands of the system $C^1\Sigma—B^1\Sigma$.

The fact that the latter two bands appear in the absorption spectrum at room temperature shows that Crawford and Shurcliff's analysis of the band-system $C^1\Sigma—B^1\Sigma$ does not conform to reality. Evidently, in this system, it is the band 2587.3 Å which must be regarded as zero band. Moreover, the term $B^1\Sigma$ should be apparently identified with the normal term of the CS molecule, namely $X^1\Sigma$.

Thus, the rotational analysis of the bands 2587.3 and 2674.5 Å on which Crawford and Shurcliff are basing the distinction between the terms $B^1\Sigma$ and $X^1\Sigma$ becomes somewhat doubtful. The close agreement between

the vibrational frequency of the term $C^1\Sigma$ calculated from the difference of the frequencies (1267 cm^{-1}) corresponding to the band-heads 2505.3 and 2587.3 Å and that (1278.6 cm^{-1}) of the normal term of the CS molecule leads us to suppose that the emission spectrum might be obscured by the overlapping of some of the bands (in particular of the bands 0'0'' and 1'1'',0'1'' and 1'2'') which might account for the conclusions drawn by Crawford and Shurcliff.

Some of my photographs show faint carbon disulphide absorption bands in addition to those of CS. The formation of CS and CS_2 radicals in the discharge tube filled with sulphur vapour proved to be due to traces of vaseline oil, from the heating bath which got into the tube accidentally*.

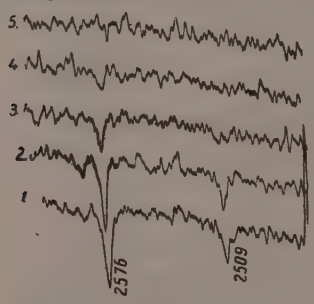

Fig. 1.

In the experimental arrangement used, the gas from the discharge tube had to travel over a distance of more than 100 cm before it reached the absorption chamber for spectral analysis. The presence of the CS radical at this great distance points to a comparatively high chemical stability of the CS radical which may be regarded as the analogue of the extremely inert carbon monoxide. A rough estimate of the stability of the CS radical can be made from the study of the microphotograms on Fig. 1 taken in the following order: 1) for the first spectrum the gas was drawn off with the tube still operating; 2) the second spectrum was taken a minute after stopping the discharge and disconnecting absorption chamber and pump; 3), 4) and 5) the same as 2) but corresponding to intervals of 2, 3 and 4 minutes respectively.

We may notice a gradual decrease of the absorption with time, beginning with the intense bands in the photograms 1) and 2) to the hardly noticeable bands in the last photogram. It follows that, under the given experimental conditions (at a pressure of some 0.05 mm and at room temperature), the average life-time of the CS radical—which may be regarded as a criterion for chemical stability—is of the order of several minutes. It must be added that in the above experiments no special care was taken to secure absolute purity of the apparatus (thus, the absorption of the CS radical and therefore its concentration was found to decrease considerably upon admission of a small amount of SO_2 into the discharge tube). It is therefore highly probable that, under better controlled experimental conditions, the life-time of the CS radical would show a much higher value.

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* I succeeded also in obtaining the above CS absorption bands in the discharge through the CS_2 vapour.

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PHYSICS

INVESTIGATION OF THE FREQUENCY OF THE OH-GROUP IN BINARY MIXTURES BY MEANS OF COMBINATION DISPERSION

II. COMBINATION SPECTRUM OF SOLUTIONS OF METHYL ALCOHOL IN CCl_4 and $CHCl_3$

By V. I. MALYSHEV

(Communicated by L. I. Mandelstam, Member of the Academy, 4.VII.1938)

The investigations of Landsberg and Ukholin (1) have shown that the sharp line of combination dispersion observed in the vapours of CH_3OH corresponds only to isolated molecules. Isolation in this case should be understood as the absence of any disturbing effect produced by the surrounding molecules upon the vibrations in the group OH.

The present investigation belongs to the series of works which succeeded in such an isolation by dissolving substances, containing the OH-group in different solvents.

The investigations of water solutions in dioxane and pyridine made by Landsberg and Malyshev (2) have shown that in this case one does not succeed in obtaining in the dispersion spectrum a sharp line characteristic of isolated molecules, instead of which only a considerable narrowing and shift of the band is observed. It is not altogether impossible that the explanation should be sought in the presence of oxygen atoms in dioxane molecule.

The present article contains the results af an investigation of the combination spectrum of solutions of methyl alcohol (CH_3OH) in CCl_4 and $CHCl_3$.

A careful purification of CCl_4 and $CHCl_3$ attained by means of a repeated distillation in a vacuum makes it possible to obtain liquids of high purity, whose dispersion spectra, even in case of long exposures, have almost no continuous background, which is most important when studying solutions of low concentrations. Owing to the interaction with surrounding molecules, the vibration of the hydroxyl group of OH in a methyl alcohol molecule may be observed in the dispersion spectrum of pure alcohol as a wide band with the maximum $\nu = 3362$ cm^{-1}.

In the dispersions spectrum of 1% CH_3OH in CCl_4 instead of one wide band three sharp lines are observed, which correspond to the three exciting lines 3650, 3655 and 3663 Å (Fig. 1). This line of the combination spectrum corresponds to the frequency $\nu = 3647$ cm^{-1}; with regard to sharpness it is not inferior to the line observed in vaporous CH_3OH. With respect to the maximum of the band of pure alcohol the line is displaced by 279 cm^{-1}; with respect to the line observed in CH_3OH vapours, where $\nu = 3676$ cm^{-1}, however, it is shifted too. This shift may be accounted for by the fact that the molecules of alcohol are divided not by a vacuum, but by the molecules of the solvent (CCl_4). The appearance of a sharp line instead of a wide band obviously points to the presence in the solution of isolated molecules of CH_3OH. Similar sharp lines are observed in 2% CH_3OH solution in CCl_4.

In the spectrum of 5% CH_3OH solution in CCl_4, alongside of sharp lines a band is also observed, which occupies the same place as in pure CH_3OH.

This solution obviously contains aside from isolated molecules of CH_3OH associated molecules too, i. e. molecules united into complexes where the vibration of the OH-group is disturbed.

The raise of alcohol concentration (10, 20, 50%) has no effect upon the position of the line or of the band. However, the intensity of the band increases, while that of the line is slowly reduced. This points to a reduction of the number of isolated molecules, though the latter occur even in very strong solutions. In a 50% solution of CH_3OH the number of alcohol molecules is twice that of the solvent molecules and yet the line is observed which points to the presence of isolated molecules. The isolation should obviously be understood not only as the molecules of alcohol being merely surrounded by those of CCl_4, but also as a definite orientation of the alcohol molecules among themselves. In other words, the CH_3OH molecule can be regarded isolated even in the case when it is surrounded with other molecules of CH_3OH, provided the latter are oriented as to produce no disturbance of the vibration of the OH-group. Further were investigated solutions of CH_3OH in $CHCl_3$—chloroform (2, 5, 10, 20, 50 and over 50%). Chloroform differs from CCl_4 in that its electrical moment is $\mu = 1.\ 1510^{-18}$. In the spectrum of 2% CH_3OH dissolved in $CHCl_3$ instead of band also three sharp lines are observed with a frequency $\nu = 3630\ cm^{-1}$; these lines are somewhat wider than those observed in CCl_4 solutions. Thus, the change of the solvent was expressed in a slight displacement of the vibration frequency (17 cm^{-1}) of isolated OH molecules, and in the width of the line. With the increase of alcohol concentration aside from the line the band also appears; the brightness of the latter is growing with the increase of concentration. However, differently from CCl_4 solutions, the band appears here at high concentrations only. If we compare spectra in CCl_4 solutions with those in solutions of $CHCl_3$ at the same concentrations, then the relative intensity of the band in CCl_4 considerably exceeds that in $CHCl_3$ (Fig. 2).

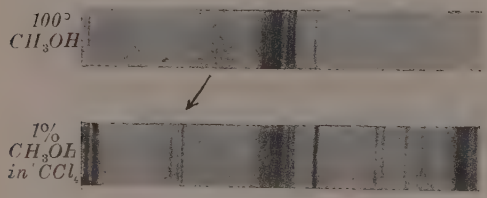

Fig. 1.

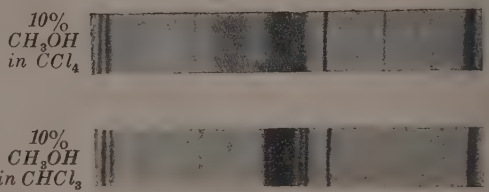

Fig. 2.

Thus, the presence of the electric moment in the solvent molecules but slightly changes the frequency of OH itself; although, interacting with the moment of alcohol molecules, it prevents their reciprocal orientation favourable for the disturbance of OH vibrations. An attempt to detect the line of isolated molecules at concentrations exceeding 50% is prevented by the fact that the line grows very bright, its edges overlapping the weak line.

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PHYSICS

SCATTERING OF NEUTRONS IN FERROMAGNETICS

By A. MIGDAL

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Bloch (1) was the first to point out that scattering due to the interaction between the magnetic moment of the neutron and the magnetic field of the atom, may play a noticeable part in the passage of neutrons through a matter. Bloch (1), Schwinger (2) and other obtained different expressions for the cross-section of scattering.

The results obtained by the above writers can be summarized in the following equation for the differential cross-section of scattering (including also the nuclear cross-section):

$$\Phi_\omega = \sigma_\omega \left| 1 \pm \frac{\gamma_n \gamma_a}{\frac{1}{2\sigma_\omega^2}} \cdot \frac{e^2}{mc^2} (\cos^2 \vartheta_0 - C) F(\mathbf{q}) \right|^2, \qquad (1)$$

where σ_ω is the cross-section of nuclear scattering;

γ_n, γ_a — the magnetic moments of the neutron and the atom in the nuclear and the ordinary Bohr magnetons;

ϑ_0 — the angle between the direction of magnetization of the atom and the difference $\mathbf{q}$ between the vectors of propagation of the incident and the scattered wave;

$F(\mathbf{q})$ — the atomic factor.

The positive sign corresponds to a parallel, and the negative sign to an anti-parallel orientation of the neutron spin about the magnetic moment of the atom.

Various writers obtained different values for the constant C. For instance, Bloch obtained $C=0$ and Schwinger $C=1$.

Bloch explained this discrepancy by the dependence of the calculation made on the assumption of the nature of the magnetic moment of the neutron. Thus, according to Bloch, in the calculation made by Schwinger, the neutron is treated as ampère current, while in his own calculations the neutron is regarded as an actual magnetic dipole. Further, a comparison of the cross-section obtained with the experimental data ought to provide evidence as to the magnetic nature of the neutron.

The object of the present paper is to show that the cross-section does in fact not depend on the magnetic nature of the neutron and that the expression obtained by Schwinger ($C=1$) is the only correct one.

In calculating the cross-section of scattering it is necessary to know the kind of potential energy of interaction between the neutron aud the

atomic field. We shall disregard, as it was also done by Bloch and Schwinger, the distortion in the electron density, due to the passing neutron, i. e. we shall consider the scattering in a given atomic field*. This assumption is also the premise of the Born method, which was applied by the above writers. Since the atomic field varies noticeably only within a range of lengths comparable with its own dimension, the additional energy of the neutron in such a field will be determined by the following equation:

$$-\mu_n \cdot \mathbf{H}, \tag{2}$$

where μ_n is the magnetic moment of the neutron and

$\mathbf{H}$ — the magnetic field of the atom.

A deviation from this equation is possible only for fields which vary within the range of the dimension of the neutron since the magnetic nature of the latter can be revealed only in these fields. It is clear, therefore, that the magnetic scattering of the neutron cannot depend on its structure.

Let us now evaluate the magnetic field of the atom.

Is would seem that it ought to be calculated as follows; disregarding the field due to the orbital motion of the electrons (ferromagnetic),

$$\mathbf{H} = \int \left\{ \frac{\mu_a}{r^3} - \frac{3(\mu_a \cdot \mathbf{r})\,\mathbf{r}}{r^5} \right\} |\Psi|^2 \, d\tau; \tag{3}$$

(3) is the classical expression for the field of the magnetic dipole, distributed with density $|\Psi|^2$. That was the expression used by Bloch. This equation, however, is valid only if justified by Dirac's theory or by Pauli's theory which, in our case, is equivalent to the former.

Let us show that such a method of calculation is not quite accurate.

According to Pauli's theory, the magnetic field due to the spin should be calculated by the following equation:

$$\mathbf{H} = \int \frac{\operatorname{rot} \mathbf{M} \cdot \mathbf{r}}{r^3} \, d\tau \tag{4}$$

where M is the density vector of the magnetic moment having the known form:

$$\mathbf{M} = \mu_a \varphi^+ \sigma \varphi.$$

For a spin directed along the Z-axis this equation gives

$$M_x = M_y = 0; \quad M_z = \mu_a |\Psi|^2 \tag{5}$$

where Ψ is Schrödinger's electron function.

For the orientation of the neutron spin parallel or anti-parallel to the spin of the atom the interaction energy is

$$\mp \mu_a H_z .$$

We shall therefore in our further discussion calculate only H_z.

From equation (4) and (5) we obtain

$$H_z = \mu_a \left\{ \int \frac{\nabla |\Psi|^2 \cdot \mathbf{r}}{r^3} \, d\tau - \int \frac{\partial |\Psi|^2}{\partial \zeta} \frac{\zeta - z}{r^3} \, d\tau \right\}. \tag{6}$$

Applying Green's formula, it is easy to reduce (6) to:

$$H_z = \mu_a \left\{ \int |\Psi|^2 \frac{1 - 3\cos^2 \vartheta}{r^3} \, d\tau - 4\pi |\Psi|^2_{r=0} - \int |\Psi|^2 \frac{\cos\vartheta \cos nz}{r^2} \, d\sigma \right\}. \tag{7}$$

* It may be shown by a direct calculation that this distortion is negligible.

The surface integral is taken over the surface encircling the point $r=0$.

The first term of the expression (7) is equal to (3) used by Bloch. This expression therefore does not coincide with the correct equation. Since equation (6) does not depend on the method of calculation (as may be proved, the integrant function has no singularity at $r=0$), the same applies to the sum of integrals (7) but not to each of them separately. As the third term of (7) depends on the shape of the surface cut off round point $r=0$, the first term also depends on the method of calculation and in such a way that the sum has no ambiguity. Thus, the incorrect expression (3) used by Bloch depends on the method of calculation. This mathematical factor was mistaken by Bloch for the evidence of the calculation on the «form» of the neutron.

In order to obtain correct results from (7), it is necessary in calculating the volume integral to eliminate from integration the region over the surface of which the integration is carried out in the third term of the equation. The expression will have the simplest form, if the choice of the surface results in the elimination of the last two terms. One of such surfaces is the surface of a thin disc having its axis directed along the Z-axis. Then (7) will become identical to (3) under the extra condition that the region having the form of a disc should be excluded from integration. The expression for the cross-section obtained in this manner will then agree with that obtained by Schwinger. This is as it should be, since Schwinger used in his calculation Dirac's expression for the atomic magnetic field, and thus avoided the error involved in the application of an incorrect equation (3).

Bloch's statement ([3]) as to the dependence of the hyperfine structure on the nature of the magnetic moment of the nucleus is also incorrect. It is easy to see that the magnetic field produced by electrons near the nucleus remains practically constant within the range of nuclear dimensions (this result remains valid also for Dirac's Ψ-functions of S-state, which possess singularities as the origin of the co-ordinate). Therefore for the energies of interaction the expression (2) is valid, irrespective of the magnetic structure of the nucleus.

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CHEMISTRY

ON THE OXIDATION OF ALKYL-ANTHRACENES, ALKYL-ANTHRAQUINONES AND THEIR DERIVATIVES

I. THE OXIDATION WITH CHROMIC ANHYDRIDE OF β-METHYL-ANTHRAQUINONE TO ANTHRAQUINONE-β-CARBOXYLIC ACID

By M. A. ILJINSKY, Honorary Member of the Academy, L. G. GINDIN and V. A. KASAKOVA

There are rather abundant experimental data on the oxidation of β-methyl-anthracene and β-methyl-anthraquinone to anthraquinone-β-carboxylic acid. Nevertheless, a great deal of very important facts remained entirely uninvestigated. This is the case with β-methyl-anthracene and β-methyl-anthraquinone, to say nothing of their derivatives, substituted in the nucleus, which have scarcely been discussed in literature. Further, the oxidation of other alkyl and polyalkyl anthracenes and anthraquinones, not to mention their derivatives, remains unstudied altogether. We have therefore made an attempt to investigate systematically this field of the chemistry of anthracenes left hitherto almost intact. By studying the influence of the constitution of alkyls, their position in the rings, the presence of some other substitutes in the nucleus and the nature of the oxident, the dissolving medium and other factors on the processes of oxidation of alkyl-anthraquinones we hope to find out sooner or later the regularities which control this process, and to compare them with the principles underlying the oxidation of the side chains in the series of benzene and naphtalene.

The interest presented by this problem is not a merely theoretical one. The anthraquinone-carboxylic acids and, particularly, their derivatives are used as initial materials for the syntheses of indigoids and especially of indanatrenic colours. For this reason the study of their properties and procedures of their preparation may still more extend the field of their application.

A detailed investigation in the processes of oxidation of β-methyl-anthraquinone to anthraquinone-β-carboxylic acid was one of the first problems to solve. Apart from some peculiarities in the behaviour of β-methyl-anthraquinone and β-methyl-anthracene, there are extensive literary data on the oxidation of these compounds, which will be considered separately. J. Weiler (1) and O. Fisher (2), who prepared β-methyl-anthracene as far back as in 1874, oxidized it then to anthraquinone-carboxylic acid by boiling it with chromic acid in glacial acetic acid. W. Hammerschlag (3) described later a method of oxidation of β-methyl-anthraquinone to the corresponding carboxylic acid. This method consists in boiling a solution of β-methyl-anthraquinone in glacial acetic acid for six hours with an excess of chromic acid.

However, these authors do not mention the yields. We meet with the quantitative data for the first time in the papers by Börnstein[4] and Liebermann and G. Glock[5]. Börnstein oxidized β-methyl-anthraquinone dy dissolving 1 part of same in 6 parts of conc. H_2SO_4 and 1 part of water and introducing into this gruel 2.5 parts of potassium bichromate and then heating the mixture to 110—120°. The yield of anthraquinone-carboxylic acid was as large as 30% of the theoretical. Liebermann and Glock oxidized β-methyl-anthraquinone in another way. They introduced gradually 1½ parts of chromic anhydride dissolved in water to 1 part of methyl-anthraquinone in glacial acetic acid and then heated the mixture for three hours in a water bath. The yield in this case came up to 40% of the theoretical. H. Limpricht and O. Wiegand[6] prefer the method of Börnstein. H. Meyer[7] described a method of Eichholz, which according to him permits of determining up to 80% of β-methyl-anthracene in crude anthracenes in the form of anthraquinone-β-carboxylic acid. We were unable to become acquainted with Eichholz's dissertation, but oxidizing β-methyl-anthracene under the conditions described by H. Meyer, we have obtained the acid in a maximum yield of 38% of the theory. The greatest yield we succeeded to obtain oxidizing β-methyl-anthraquinone under the conditions of Kafuku and Sebe[8] but isolating simultaneously anthraquinone-carboxylic acid in the form of its ammonium salt (which was not done by the Japanese authors), was 67% of the theory. Thus, all the procedures of oxidation of β-methyl-anthraquinone to anthraquinone-carboxylic acid known to us gave a result which is far from being qualitative.

On account of this we have set ourselves the purpose to develop a procedure of quantitative conversion of β-methyl-anthraquinone to anthraquinone-β-carboxylic acid. The possession of such a method, aside from its practical importance, would facilitate to determine the influence of the variety of factors on the course of oxidation and on its quantitative results.

Lack of space does not permit us to give here an account of all the experiments made in the pursuit of the optimal conditions of oxidation. The results of these experiments will be described elsewhere. Here we would but notice that these experiments have shown a decisive influence of four factors on the oxidation of β-methyl-anthraquinone: the temperature of oxidation, its duration, the amount of Cr_2O_3 and, what is of particular interest, the amount of water. Taking all this into consideration we have found a method of almost quantitative oxidation of β-methyl-anthraquinone to anthraquinone-carboxylic acid. The procedure is the following: 1g of β-methyl-anthraquinone (m. p. 176°) was dissolved under gentle warming in 50 ml of glacial acetic acid. Then, 3.0 g of finely ground anhydrous chromic anhydride were gradually added under vigorous stirring into a three-necked flask containing the solution. The flask was warmed to 70° on a water bath. The oxidation process continued at 70° for 8 hours. On expiration of that time the contents were cooled and then diluted with 400 ml of water. The resulting deposit was filtered off and washed with water till the disappearance of chromium salts from the washings. The precipitate was transferred from the filter into an Erlenmeyer flask and then treated under boiling with a dilute ammonia solution till the filtrate ceased to form precipitate being acidified. The solution of ammonium salt of the carboxylic acid was filtered and the filtrate acidified with hydrochloric acid. The deposited anthraquinone-carboxylic acid was filtered off on a Schott filtre, washed with water and dried to constant weight. The yield of the acid was 94—94.5% of theory. The acid obtained was exceedingly pure with m. p. 291—292°.

The results of some of the most typical syntheses are reported belon (Table 1).

Table 1

Oxidation of β-Methyl-Anthraquinone after the Method of the Authors

Exp.	Weighed portion of β-methyl-anthraquinone in g	Yield of anthraquinone-β-carboxylic acid	
		in g	in % to the theory
1	1.000	1.069	94.2
2	1.000	1.069	94.2
3	1.000	1.067	94.0
4	1.000	1.072	94.4
5	1.000	1.077	94.9
6	1.000	1.086	95.7
7	5.000	5.408	95.0

Table 2

Loss of Acid Due to Its Solubility during the Process of Isolation

Weighed portion of anthraquinone β-carboxylic acid	Amount of recovered acid		Loss in %	Average loss in %
	in g	in %		
1.003	0.9984	99.5	0.5	0.5
1.000	0.9936	99.4	0.6	
1.000	0.9972	99.7	0.3	

Table 3

Effect of Chromic Anhydride on Anthraquinone-β-Carboxylic Acid under the Conditions of Oxidation of β-Methyl-Anthraquinone

Weighed portion of anthraquinone-β-carboxylic acid	Amount of recovered anthraquinone-β-carboxylic acid		Loss in %	Average loss in %
	in g	in %		
1.000	0.966	96.6	3.4	3.1
1.000	0.973	97.3	2.7	
1.000	0.968	96.8	3.2	

Scrupulously freezing out the acetic acid and thoroughly drying the chromic anhydride we have succeeded to increase the yield af anthraquinone-β-carboxylic acid to 96% of the theory (exp. 5, 6 and 7). The deficit of 4 to 5% of the acid is to be explained by the unavoidable losses of material during the isolation of anthraquinone-carboxylic acid and, above all, by the destruction of the acid during the oxidation process (Tables 2 and 3).

Slightly varying the conditions one may possibly succeed in reducing this destruction to the minimum and thus attain the theoretical yield.

At the present time we are developing a technical procedure of oxidation of β-methyl-anthraquinone to anthraquinone-carboxylic acid.

Summary

A method of oxidation of β-methyl-anthraquinone which permits of obtaining anthraquinone-β-carboxylic acid in a yield of 96% of the theory has been developed.

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CHEMISTRY

ON THE OXIDATION OF ALKYL-ANTHRACENES, ALKYL-ANTHRAQUINONES AND THEIR DERIVATIVES

II. THE OXIDATION OF 3-METHYL-ANTHRAQUINONE WITH CHROMIC ANHYDRIDES TO ANTHRAQUINONE-β-CARBOXYLIC ACID AS INFLUENCED BY WATER

By M. A. ILJINSKY, Honorary Member of the Academy, L. G. GINDIN and V. A. KASAKOVA

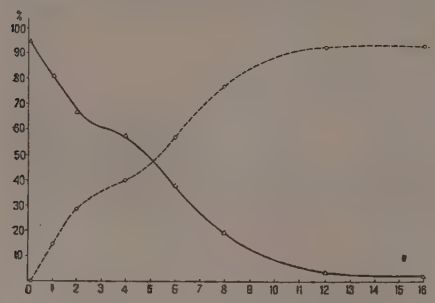
In the first part of this series (1) we have described a method we developed for qualitative oxidation of β-methyl-anthraquinone to anthraqui-

The Influence of Water on the Process of Oxidation with Chromic Anhydride of β-Methyl-Anthraquinone in Acetic Acid according to the Method of the Authors of this Paper

The amount of water added in ml	The amount of anthraquinone-carboxylic acid obtained			The amount of the remaining β-methyl-anthraquinone			The result for methyl-anthraquinone in % as an average	Average losses mainly connected with the destruction of nucleus
	in g	in % of the theoretical	An average % of the theoretical	in g	in %	Average in %		
0	1.086	95.7	95.3	0	0	0	95.3	4.7
0	1.077	94.9		0	0			
1	0.911	80.2	80.6	0.152	15.2	14.8	95.4	4.6
1	0.920	81.0		0.144	14.4			
2	0.757	66.7	67.3	0.283	28.3	28.0	95.3	4.7
2	0.767	67.6		0.276	27.6			
2	0.780	68.7		0.262	26.2			
2	0.751	66.2		0.298	29.8			
4	0.658	58.0	56.7	0.382	38.2	39.8	96.5	4.5
4	0.630	55.5		0.414	41.4			
6	0.411	36.2	38.1	0.601	60.1	58.1	96.2	3.8
6	0.454	40.0		0.562	56.2			
8	0.200	17.6	19.4	0.798	79.8	78.1	97.5	2.5
8	0.242	21.3		0.765	76.5			
12	0.044	3.9	4.0	0.9512	95.12	94.2	98.2	1.8
12	0.046	4.1		0.9324	93.24			
16	0.022	1.9	2.0	0.965	96.5	96.3	98.3	1.7
16	0.024	2.1		0.962	96.2			

Note. A weighed portion of 1 g of β-methyl-anthraquinone was taken in all experiments.

none-β-carboxylic acid. As we have already mentioned the anhydrousness of acetic acid and CrO_3 is one of chief conditions of successfull oxidation. This inhibiting action of water on the oxidation of a side chain, previously notified by one of us (2), is of considerable interest and therefore we have undertaken to trace quantitatively this influence on the process of oxidation of β-methyl-anthraquinone to anthraquinone-β-carboxylic acid. The procedure was as follows: we oxidized β-methyl-anthraquinone under the conditions described in the first part with the only difference that different amounts of water were added to 50 ml of glacial acetic acid, without disturbing the homogeneity of the medium. The results of this series of experiments are tabulated above and plotted on the curve.



——— anthraquinone - β - carboxylic acid

— — — β-methyl-anthraquinone

Oxidation of β-methyl-anthraquinone with chromic anhydride as influenced by water

We were perplexed by the experiment with 2 ml of water. But having repeatedly checked it and determined the point for 1 ml of water we became persuaded that the curve has a peculiar character within this range of dilution with water. We see that the yield of anthraquinone-β-carboxylic acid can be reduced from maximum to minimum by varying the amount of water taken. It is of some interest to note that the losses of material connected with the destruction of the nucleus did not exceed 4.7% in all these experiments diminishing with the dilution of acetic acid with water.

Thus, water is a factor of very delicate regulation of the process of oxidation of β-methyl-anthraquinone with chromic anhydride. The inhibiting effect of water extends, probably, on many similar processes of oxidation. The investigation of the mechanism of this phenomenon is in progress.

Summary

The inhibiting effect of water on the process of oxidation of β-methyl-anthraquinone to anthraquinone-β-carboxylic acid was investigated.

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CHEMISTRY

INVESTIGATIONS OF THE CORROSION OF METALS BY NON-ELECTROLYTES

THE ACTION OF LIGHT HYDROCARBON FUEL ON METALS AND ALLOYS. VI

By L. G. GINDIN

(Communicated by M. N. Iljinsky, Honorary Member of the Academy, 27.VI.1938)

The Action of Cracking-Benzines on Lead

Continuing our study of the action of cracking-benzines on metals ([1—6]) we found that after autoxidation cracking-benzines become able to produce a very strong corrosive effect on lead. In general the corrosion process of Pb is characterized by the same regularities that were observed by us when studying the corrosion of other metals by cracking-benzines. Experimental data (Table 1 and Figure 1) point to the existence of a definite dependence of corrosion upon the degree of oxidation of the fuel. The more advanced is the autoxidation of cracking-benzine in the given experiment, the greater is the destruction of the metal sample. Developing at first as a rectilinear function of the rate of autoxidation, the corrosion process afterwards gradually tends to diminish. An analogous phenomenon has already been observed before ([4,5]). Apparently the resin and the products of corrosion which cover the lead protect it from further attacks of the aggressive compounds (compare, for instance, experiments 186 and 24, 73 and 74).

Action of cracking-benzines of Baku on lead

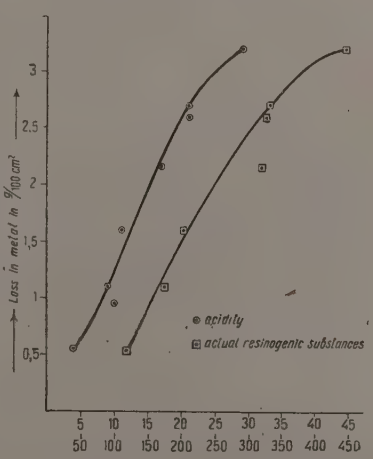

Fig. 1. Loss in metal as function of concentration of acids and actual resinogenic substances in benzines.

The cracking-benzine from Grozny is much less aggressive than that from Baku (Table 2).

On the whole the dynamics of the cracking-benzine constants display what has been called concomitance, i. e. conformity in the fluctuations of separate constants, the variations in one constant corresponding to variations in another (Figures 2 and 3). We shall discuss this congruous dynamics

Table 1

Action of Baku Cracking-Benzine on Lead

Composition of benzine see [2] and [4]. Composition of lead: 0.05% Fe; 0.15% Zn; 0.1% Bi; 0.1% Cu. 250 ml of benzine was used in each experiment

№ experiment	Duration in days	Loss of metal in g/100 cm²	Dynamics of the benzine constants					
			Sp. weight 15°/15°C	Peroxide number	Iodine number	Acidity	Actual resino-genes	Resins
24	710	13.2	0.774	4.90	66.8	208	1000	Not de-
186	535	3.2	0.754	0.90	85.1	29	444	termi-
181	528	2.7	0.753	0.74	87.4	21	331	ned
188	535	2.6	0.753	1.76	87.6	21	325	
187	535	2.15	0.752	0.97	87.5	17	320	
183	528	1.6	0.751	0.68	89.8	11	203	
179	528	1.1	0.750	0.57	91.6	9	178	
184	528	0.95	0.750	0.72	91.4	10	185	
185	535	0.55	0.748	0.45	93.3	4	124	

Table 2

Action of Grozny Cracking-Benzine on Lead

Composition of benzine see [5]. Composition of lead—the same as above. 250 ml of benzine were used in each experiment.

72	690	1.5	0.764	5.38	83.0	385	1110	501
73	690	0.7	0.746	2.45	100.9	73	522	66
74	690	0.6	0.739	0.40	107.1	11	245	26

Note. In all the experiments when the lead samples were analyzed, they were found to be coated with a dense layer of a yellowish-white precipitate impregnated with resin. The bottom of the vessels were covered with resin. In a number of cases needle-like crystals appeared on the walls of the vessels. In all the experiments the benzine stayed transparent and almost colourless.

of the constants, illustrating some essential features of autoxidation, as well as the effect of metals, and particularly of lead, in the next paper. In the meantime we shall make note of only two of the peculiarities of cracking-benzines in our experiments, namely, the comparatively low acidity in the experiments with the Baku cracking-benzine, which is probably due to the intense corrosion of the lead, and the high peroxide number in the experiments with both of the benzines.

The lead samples became coated with a dense layer of corrosion products. The procedure of eliminating these products from the metal surface was the following: first the samples were treated with acetone and ethyl alcohol in order to take off the resins. Then they were put into test tubes with distilled water, which were submerged in a boiling water bath for 20—30 min. In this way the samples were freed from the greater part of precipitate, which had stuck to them very densely. Finally the samples were given a cathode treatment for 2—3 min. in a 10 per cent solution of Na_2SO_4 with a graphite anode and a cathode current density of 5 A/100 cm² in order to remove the deepest traces of corrosion. Having done all this we succeeded in determining how far corrosion had actually gone. Control experiments showed that under the same treatments clean lead samples change in weight within 0.0005 g.

After the precipitates had been removed from the samples, we found that the corrosion was of a local kind. We have observed this phenomenon in other metals too, and shall describe it in detail in the next paper.

A microchemical investigation of the precipitates from individual samples of lead showed that they were composed of lead, organic compounds and carbonic acid. Taking the precipitates* from several samples, we mixed them and found the ratio between lead and carbonic acid in them. Thus, we found what interested us most—the ratio between lead and carbonic acid for the «average» deresinated precipitate. We determined CO_2 and Pb in the usual manner: CO_2—by decomposing the precipitate with 10 per cent hydrochloric acid and absorbing it in $^1/_{20}$ N barium hydroxide; lead—in the form of its sulphate.

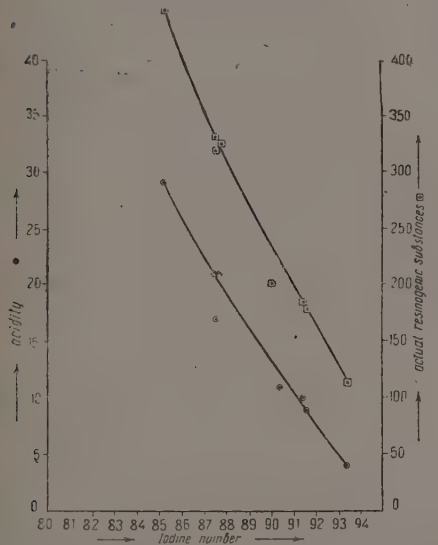

Fig. 2. Acidity and actual resinogenic substances of cracking-benzine as function of its iodine number.

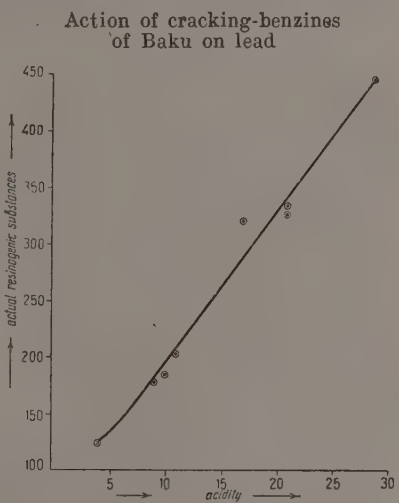

Fig. 3. Actual resinogenic substances as function of cracking-benzine acidity.

Quantity of precipitate used—0.8742 g. Results: $CO_2 = 0.0652$ g; $PbO = 0.5669$ g.

Thus, this analysis gives us grounds to conclude that 58.26 p. c. of the lead in the precipitate when on metal is, probably, in the form of lead carbonate $PbCO_3$; the rest of it is to be expected in the form of organic acid salts.

This is not the first time we have met with CO_2 in the composition of the products of the corrosion of metals by cracking-benzines. We found large quantities of carbonic acid in the precipitate on zinc and also in the precipitate on magnesium**. Consequently we have here a rather general and characteristic phenomenon.

If this is so what then is the process of formation of carbonates?

It can hardly be supposed that the carbonates could form by the CO_2 reacting directly with the metals. We treated samples of commercial lead with hexane, periodically saturated with CO_2 for 20 days, but did not observe the least change in the metal (Table 3). Taking into account the differences in the conditions of these experiments and those with the cracking-benzines,

* Which were obtained after filtering the aqueous suspensions. The filtrates were not analyzed. They contained only traces of lead.

** Similar observations have been published. For instance, Uspensky and Ladyjhnikova [7] found, quantitatively, it is true, CO_2 in the products of the corrosion of lead by Grozny benzine (direct distillation).

Table 3

The Action of Hexane Saturated with Carbon Dioxide on Lead*

№ exper.	Weight of metal	
	before experiment	after experiment
1	1.9987	1.9987
2	1.9644	1.9644
3	2.0390	2.0392
4	2.0684	2.0682

for instance their duration, we should probably have observed some corrosion in the lead, if a solution of CO_2 in hexane were aggressive. Apart from this, it is in contradiction with the relation we observe between the extent of corrosion and the acidity of the cracking-benzines and the degree of their oxidation, to consider those carbonates as primary corrosion products. This relation, which we have no grounds to suppose indirect, shows us, on the contrary, that the primary corrosion products are none other than the organic acid salts. The conversion of these salts results in the formation of carbonates. It is difficult to say with confidence what these changes consist in, since after all we have no idea of the nature of the acids which form when the cracking-benzines are autoxidized. It is more than probable, however, that carbon dioxide displaces the organic acids from their compounds with the metals. Carbon dioxide, which is formed during autoxidation, gradually displaced the organic acids from their salts, which were probably more soluble in benzine than the carbonates, as a result of which equilibrium was constantly shifted towards the latter. But the benzine acids, even of higher concentrations, did not exert any influence upon the carbonates. Analogous phenomena have been reported on the action of CO_2 on acetates, naphthenates and other salts ([8], [9], [10], [11], [12], [13]).

All the above deliberations are, of course, merely hypothetic and require experimental grounding. We intend to do this in the near future, for we believe that a problem such as the relations of CO_2 to non-aqueous salt solutions, especially if treated on a larger scale, is worthy of close attention.

Conclusions: 1. The action of cracking-benzines on lead has been studied. 2. It had been shown that as a result of autoxidation cracking-benzines produce a very strong corrosion of lead. The extent of corrosion depends on the length of autoxidation. 3. The composition of the corrosion products has been studied, and it has been found that about 60 per cent of the lead contained is in the form of carbonate. 4. Deliberations have been made as to the way in which carbonates are formed when metals are acted upon with cracking-benzines.

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* Lead plates were hung in Drecksel flasks half-filled with hexane. Several times a day for 20 days CO_2 was passed through the hexane. On the way from the Kipp's apparatus the carbon dioxide was dried with phosphorus pentoxide on pumice. Externally after experiment the metal did no change at all.

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CHIMIE

LA CONCENTRATION DE L'ISOTOPE LOURD DE L'OXYGÈNE ET L'ANALYSE ISOTOPIQUE DE L'EAU

Par O. Ch. SCARRE et A. E. BRODSKY

(Présenté par A. N. Frumkin, de l'Académie, le 2.VII. 1938)

Nous avons appliqué la distillation fractionnée de l'eau afin de concentrer l'isotope lourd O^{18} de l'oxygène. Selon Huffman et Urey (1) ce procédé est particulièrement avantageux pour ce but. Après quelques expériences préliminaires avec une colonne en verre de 180 cm de hauteur (2), nous avons construit une colonne métallique beaucoup plus efficace semblable à celle de Urey. Les plateaux plats y sont remplacés par des cônes renversés. Les cônes tournant sur un arbre axial sont suivis par des cônes immobiles avec des remparts qui forment la paroi de la colonne. Notre colonne est 200 cm de hauteur et 15 cm de diamètre, elle contient 400 cônes estampés, avec un angle de 30° choisi à titre d'essais spéciaux. Un petit ballon chauffé à l'électricité est placé au pied de la colonne. En consommant 1.5 kW il évapore 1.2 l/h d'eau. L'eau fraîche qui est ajoutée durant tout le temps de la distillation est portée sur le cône supérieur en passant une soupape, un compte-gouttes et un échangeur de chaleur. La vapeur est aspirée par une pompe à huile dont le travail continuel assure une pression réduite de 20—25 cm Hg. La colonne et ses accessoirs sont faits en cuivre de 0.5 mm d'épaisseur. La description détaillée et le dessin de l'appareil seront donnés dans une publication prochaine. La vitesse de rotation fut adoptée 250 tours/minute environ. Cette vitesse est optimale pour notre colonne ainsi que l'ont montré des expériences préliminaires.

La composition isotopique du produit était déterminée en mesurant la différence Δd des densités et Δn des indices réfractaires de l'échantillon et de l'eau initiale. Les détails de l'analyse ont été décrits dans une publication précédente (3) où il a été indiqué que l'ignorance de la valeur exacte de l'influence du contenu en H_2O^{18} sur l'index réfractaire de l'eau mène à une incertitude considérable les résultats de l'analyse isotopique. C'est pour ça que nous avons déterminé simultanément le contenu de nos échantillons pour O^{18} par voie directe. L'excès de deuterium a été presque complètement éloigné en recombinant l'oxygène de l'échantillon avec de l'hydrogène ordinaire, produit par action de l'acide sulfurique sur le zinc. L'excès de densité résiduel est, à 2—3 γ près, entièrement dû á l'excès de O^{18}. Pour décomposer des petites quantités d'eau (jusqu'á 10 cm^3) par des courants élevés (6 A), sans que l'électrolyte soit trop chauffé, nous avons construit un électrolyseur spécial.

La comparaison des deux procédés analytiques permet de trouver la différence des index réfractaires de H_2O^{18} et de H_2O^{16}. Nous avons obtenu pour les trois échantillons les plus concentrés* les valeurs suivantes: +0.00061, −0.00076 et +0.00062 (avec une incertitude de ±0.0001) au lieu de la valeur précédente douteuse +0.0008 dont l'exactitude fut alors estimée ±100 p. c. Le nouveau coefficient ne diffère pas considérablement de celui qui a été adopté précédemment: même pour les eaux relativement concentrées, étudiées dans cet ouvrage, la correction ne dépasse guère 2—3 γ en densité. Il en est d'autant plus pour les eaux naturelles, étudiées dans la publication précédente, pour lesquelles les erreurs de détermination de Δd et de Δn ** surpassent largement les fautes possibles commises à cause de l'incertitude de la valeur du coefficient nommé. Une vérification ultérieure de la valeur trouvée est fournie par la comparaison des $\Delta d'_y$ et $\Delta n'_y$ mesurés après l'éloignement de l'excès du deuterium. Le rapport de ces différences est, selon la table 1, moyennement $7.5 \cdot 10^{-3}$, tandis que la valeur calculée est $6.5 \cdot 10^{-3}$. La différence des indices réfractaires de H_2O^{18} et de H_2O^{16} trouvée n'est pas très exacte, quoique suffisante pour l'analyse isotopique de l'eau. Une valeur plus exacte sera mesurée après qu'aura été obtenue une séparation des isotopes d'oxygène plus complète dans une colonne de 10 m, que nous voulons monter prochainement et dans laquelle nous espérons de recevoir un enrichissement en O^{18} de 6—8 fois.

En admettant pour H_2O^{18} pure le même Δd envers l'eau ordinaire que pour D_2O^{16} (en raison du même poid moléculaire), on trouve pour la réfraction moléculaire de H_2O^{18} (à 20° pour la raie jaune du He) une valeur en 0.015 unités plus élevée que celle de l'eau ordinaire, tandis que pour D_2O^{16} elle est en 0.038 unités plus petite que la dernière. C'est ainsi que H_2O^{18} est la plus déformable des trois molécules isotopiques de l'eau.

Table 1

№	Avant l'éloignement du deuterium		Après l'éloignement du deuterium		Δd_x	Δd_y
	Δd	Δn	$\Delta d'_y$	$\Delta n'_y$		
I	75	$-9.0 \cdot 10^{-7}$	40	$+2.5 \cdot 10^{-7}$	31	44
II	195	$-39.0 \cdot 10^{-7}$	91	$+7.0 \cdot 10^{-7}$	106	89
III	204	$-35.5 \cdot 10^{-7}$	103	$+8.5 \cdot 10^{-7}$	100	104
Reflux d'en-bas	131	$-24.5 \cdot 10^{-7}$	72	$+5.0 \cdot 10^{-7}$	67	64
Reflux d'en-haut	72	$-7.0 \cdot 10^{-7}$	—	—	26	46

La concentration des isotopes lourds a été accomplie trois fois, sans compter les expériences préliminaires. Dans la première expérience la

Table 2

№	V	w	t	$t°$	x	y	p_y	$[t_y]$	$[t_x]$
I	230	750	76	100	2.76	1.26	75	82	67
II	260	800	80	69	6.90	1.52	63	78	86
III	260	730	93	69	6.56	1.61	72	87	90
Reflux d'en-bas	—	—	—	—	4.77	1.37	—	—	—
Reflux d'en-haut	—	—	—	—	2.45	1.28	—	—	—

* Au № 1 les Δn sont trop petites pour servir à un calcul exact du coefficient.
** 0.3 γ pour Δd et $1 \cdot 10^{-7}$ pour Δn.

pression fut normale étant réduite dans les deux autres à 23—24 cm Hg. Le reflux considérablement enrichi qui restait sur les cônes après l'expérience II a été employé pour l'expérience III. Après cette dernière la plupart du reflux divisée en deux parties, de 350 cm³ chaque, a été analysée. Le contenu total en reflux de la colonne, durant le travail, a été déterminé en l'emplissant avec de l'alcool dilué et en le lavant ensuite avec une quantité déterminée d'eau. Ce contenu est près de 1000 cm³.

La table 1 contient les Δd et les Δn avant et après l'éloignement du deuterium en excès et les fractions Δd_x et Δd_y de l'excès de densités par rapport au deuterium et à l'oxygène lourd, calculées d'après les données des colonnes 2 et 3 de la table. La table 2 contient la quantité V en cm³ (à peu près constante) d'eau dans le ballon, la quantité w d'eau fraîche ajoutée en cm³/heure, la durée t en heures du fonctionnement ininterrompu de l'appareil, la temperature $t°$ d'ébullition et les facteurs x et y d'enrichissement en deuterium et en oxygène lourd, calculés d'après les Δd_x et Δd_y de la table 1 en admettant ces grandeurs égales à 17.9 γ et 171 γ dans l'eau ordinaire envers la H_2O^{16} pure.

Le nombre p des plateaux théoriques, correspondant aux conditions citées du fonctionnement de l'appareil, peut être calculé d'après la relation suivante (⁴):

$$t = \frac{\alpha V (x-1)}{w (\alpha - 1)} + \frac{H (x - 1 - \ln x)}{w (\alpha - 1) p \ln \alpha},$$

qui présente un cas particulier de la théorie de la colonne à fractionnement qui sera donnée dans notre publication prochaine. Cette relation est appliquable aussi au cas de l'enrichissement limite quand x ou y sont égaux à α^{p-1}, qui est atteint au moment $[t]$. Les coefficients de séparation α ont été pris de la publication de Wahl et Urey(⁵): $\alpha_x = 1.026$ et 1.053 et $\alpha_y = 1.003$ et 1.0065 pour 100 et 70°; $H = 1000$ cm³ est le contenu de la colonne en reflux (sans le ballon). Toutes les trois fois la concentration limite correspondante à l'état stationnaire a été obtenue. Le nombre p_y des plateaux théoriques pour les isotopes de l'oxygène est donné dans la table 2, ainsi que le temps $[t_y]$ nécessaire pour que l'enrichissement limite soit atteint. Les valeurs p_x pour les isotopes de l'hydrogène ont aussi été calculées. Les valeurs $[t_x]$ sont sensiblement égales aux $[t_y]$, mais le nombre des plateaux théoriques pour la séparation des isotopes de l'hydrogène (35—44) est la moitié de celui pour les isotopes de l'oxygène. Il en suit apparemment que la colonne atteint l'état stationnaire envers la séparation des isotopes des deux éléments en même temps, mais que son efficacité est deux fois plus petite envers l'hydrogène qu'envers l'oxygène. Il est difficile de donner ici une explication raisonnable de ce fait, qui a été aussi observé dans les expériences de Urey, Pegram et Huffman(⁶).

La théorie donne les relations suivantes pour les facteurs d'enrichissement n_1 et n_2 de la moitié d'en-bas et de celle d'en-haut du reflux:

$$n_1 = \frac{2 (x - \sqrt{x})}{p \ln \alpha}; \quad n_2 = \frac{n_1}{\sqrt{x}}.$$

Il en suit 4.5 en deuterium et 1.46 en O^{18} pour n_1 au lieu des valeurs expérimentales 4.8 et 1.37 et 1.8 en deuterium et 1.15 en O^{18} pour n_2 au lieu de 2.5 et 1.28.

La concentration en O^{18} de 60 p. c. obtenue suffit pour une étude assez exacte des réactions d'échange isotopique qui est commencée dans notre laboratoire, ainsi que pour l'emploi de O^{18} comme indicateur isotopique.

Notre colonne est équivalente à ca. 70 plateaux théoriques dans des conditions de fonctionnement indiquées, c'est-à-dire $^1/_3$ plateau théorique pour 1 cm de hauteur ou pour une paire de cônes.

Les données de cet ouvrage sont d'un charactère préliminaire. L'étude de la colonne est poursuivie, mais nous doutons qu'elle produise des changements considérables dans nos données.

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CHEMISTRY

APPLICATION OF N. S. KURNAKOV'S PYROMETER IN THE INVESTIGATION OF THE GELATINIZATION OF POTATOE STARCH

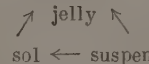
By V. I. NAZAROV and A. V. NIKOLAJEV

(Communicated by N. S. Kurnakov, Member of the Academy, 24.VI.1938)

Colloido-chemical processes have been studied up till now with regard to temperature and time (the curves of heating or cooling) either thermometrically or with a thermocouple, but without using recording instruments.

It is a well-known fact that the use of the latter greatly enhances the value of the results.

We chose the jellification of a suspension by heating as the object of our investigation. This process takes place according to the following scheme, accepted by us:



S. M. Lipatov studied the formation of the jelly from the sol visually, using a thermocouple of copper-constantan(1). We chose the other branch, viz. the formation of jelly from suspension, and used natural potatoe starch. The heating curves (a simple and a differential thermocouple) were registered on N. S. Kurnakov's self-recorder.

We used air-dry potatoe starch, washed from grated potatoe tubers with distilled water. The temperature of gelatinization of native starch (determined by T. P. Tikhomirova) after S. V. Gorbachev's (2) method was 59.8°C.

The procedure was as follows.

A glass air-clutch supplied with two sufficiently wide test tubes was put in an oil bath. One of the test tubes contained some water or an electrolyte. The other contained a concentrated starch suspension which was kept suspended by stirring all the time until the jelly formed. A gas-burner was used as the source of heat. The rise in temperature was kept even by hand. The thermocouples used were of platinum—platinum—rhodium.

The curves obtained show two stops, only the first of which was registered in all the experiments. This stop is an endothermic one while the other is exothermic. The endothermic effect takes place at 60° C, i.e. exactly at the temperature at which, according to our calculations, gelatinization should begin, and apparently has to do with the destruction of the starch grain. Its relatively small value as compared with the thermal effects in mineral systems is probably due to the positive effect of hydration and to the relatively small concentration of the suspension.

We shall not dwell upon the exothermic stop in this paper. The stop at 60°, which we propose to term «the gelatinization stop», will be discussed below.

First of all we must call attention to the absence of plateaus in the direct record, which is due to the polythermicity of the process. We can merely observe changes in the slant of the curve, the convexity of the latter being directed towards the axis of abscissae. The differential record, however, being the more sensitive is much more distinct, so that we can firmly recommend its use in the study of colloidal systems.

The change in the angle of incline of the curve in the simple record and the differential curve both show that the process, having begun at 60°, continues further. These observations fully agree with those of other investigators on this subject (3). While heating a starch suspension in a thermostat at a constant temperature until equilibrium was reached (which requires 1½—2 hours) we noticed that part of the starch grains became glutinized. At a temperature higher than this more grains glutinized. The relation between the number of glutinized grains and the temperature is expressed graphically in typical sigmoid curves.

Fig. 1.

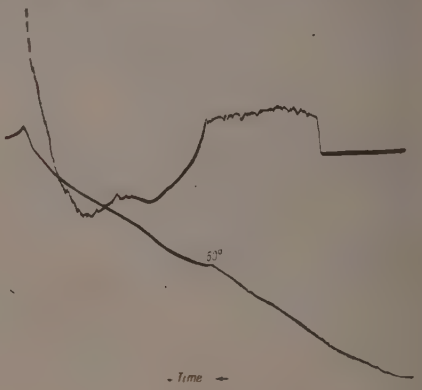


Fig. 2.

The nature of the stop which is diffuse excludes the possibility of polymorphic conversion in its usual sense at this point.

Thus, the present conception of gelatinization as being a complex process coincides with the conclusions drawn from the nature of the heating curve.

In this case swelling turned out, curiously enough, to be an endothermic process, since the heat of rupture of the bonds in the starch grains is evidently greater than the heat of hydration. This is quite possible in our oxperiments since the temperature is high.

We tried gelatinizing starch in a normal KCl solution, but found no appreciable shift of the stop of gelatinization (the temperature fell one graduation of the pyrometer scale). If the determinations are made under the same conditions after Gorbachev's method, the temperature of gelatinization proves to have fallen a little more. Judging by the differential curve, the heat effect of gelatinization in 1 *N* KCl is less than in water (see differential record).

It should be added that for all the curves the stop of gelatinization appeared only after the system had been a little overheated.

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CHEMISTRY

A STUDY OF STEREOISOMERY AND OF THE ISOMERIZATION OF SOME COMPLEX PLATINUM COMPOUNDS BY THE METHOD OF HEATING CURVES. ON ENLARGING CRYSTALS OF METALLIC PLATINUM

By A. V. NIKOLAJEV

(Communicated by N. S. Kurnakov, Member of the Academy, 24.VI.1938)

In 1926 Professor O. É. Zvyagintzev (1) obtained heating curves for Vilm's salt $[RhCl_6](NH_4)_3.NH_4NO_3$.

He obtained some very interesting results, explaining the behaviour of this complex compound under the action of heat. The points of transition and decomposition for many complex compounds were determined after the usual thermometric method by a number of investigators(2,3,4).

In one of these works the method of heating curves was tried for the study of $[Pt4NH_3]J_2$, but the curve showed neither bends nor lengthy stops. As a result of improvements made in the procedure of thermal analysis used by the Institute of General and Inorganic Chemistry, namely, the introduction of differential recording, the use of automatic apparatus, which assures of the rectilinearity of heating, and consequently, of the curves if there were no effects (5,6), made success probable in cases where it had hitherto been impossible. Besides imparting greater sensitivity compared with the thermometric method, these improvements give curves which to a great extent exclude subjectivity in the results without restricting the range of heating temperatures.

In connection with the works of N. S. Kurnakov on determining the structure of a number of complex compounds by their colour, Prof. L. A. Čugajev (7) points to that it would be desirable to develop a method permitting to determine structures in a solid state. A long time has passed since this book was written and great progress has been made in the study of solid substances (particularly X-ray analysis). Nevertheless it seemed to me that thermal analysis would also be of use in the study of the structures of complex compounds, on account of its descriptiveness and speed (2—3 hours of work).

Thanks to the kind assistance of Prof. I. I. Černiajev and A. V. Jakovlev, I was able to obtain very pure preparations for the heating curves. Thermograms were produced for ammonium chlorplatinate, Peyronnet's salt (cis-form), the chloride of Reiset's II base (trans-form) and Magnus' green salt (Fig. 1, 2, 3 and 4). In order to check the reproductiveness of the results, Peyronnet's salt was heated three times and gave the same temperatures and effects each time.

It is quite the popular opinion that complex compounds are non-equilibrial systems, i. e. they have a store of free energy which should generate with more or less ease. In other words, heating may give an exothermic

effect. This is the case, for instance, with a number of substances, particularly with natural borates when they are passing from the unstable amorphous into the stable crystalline state (6).

If we start from this proposition, the fact that there is no exothermic effect observed while decomposing ammonium chlorplatinate and the trans-form (chloride of Reiset's II base) shows that we have here an ordinary equilibrial system. The presence of exothermic effects in the cis-forms and in Magnus' salt is a clear-cut evidence of their being non-equilibrial. For the compounds mentioned above this proposition is in full accord with existing chemical data. It is interesting that just the polymer and the cis-compound are thermodynamically unstable.

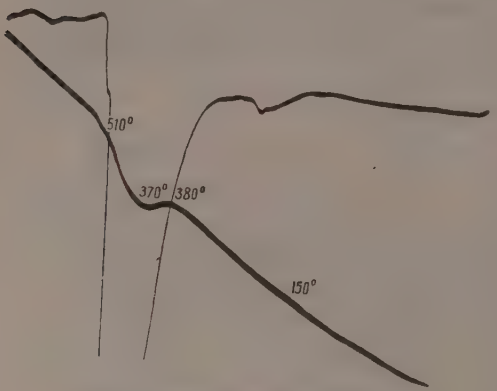

Fig. 1. Ammonium chlorplatinate.

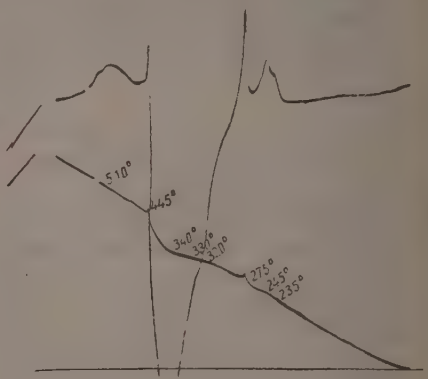

Fig. 2. Peyronnet's salt $\begin{matrix}Cl\\Cl\end{matrix}\!\!>\!Pt\!<\!\begin{matrix}NH_3\\NH_3\end{matrix}$

As seen from the figures, each of the four substances has its heating curve. The chlorplatinate and the trans-form have no exothermics at low temperatures. They differ from each other only in the temperature of decomposition and in the fact that the trans-compound shows 2 exothermics after it has decomposed. The cis-form and the polymer (Magnus' salt) have exothermics at low temperatures, which distinguishes them from the other two compounds. They themselves differ only in the number of these exothermics (cis-form—three, polymer—one) and their temperatures. The decomposition regions of these substances are strikingly alike. All the stops on the thermograms may be divided into three types:

1) cis-stops—exothermic;
2) decomposition stops—endothermic;
3) metallic platinum stops—exothermic.

This terminology will be clear from the following:

The cis-stop. Prof. L. A. Čugajev and N. K. Pšenizin (2) established a long time ago that when Magnus' green salt is heated it isomerizes into a trans-monomer (at 270°). During this transformation energy is generated. The close temperature of the exothermic (290°) on our curve shows us without further doubt that we have here to do with the same process.

The fact that the regions of decomposition of Peyronnet's and Magnus' salts fully coincide, shows that it is the same compound in both cases that decomposes, viz., the chloride of II base (trans-form). In order to check this we conducted the heat curve of the cis-form just up to the end of the exothermic effect. The crucible contained a mixture of metallic platinum and a pale yellow substance which was noticeably soluble in hot water. When dried it did not give the reaction with sulphuric acid which is chara-

cteristic for the cis-form. We doubtlessly have here Peyronnet's trans-isomer salt. This was confirmed by professor I. I. Černiajev.

Hence the name «cis-stop» is now explicit: the substances which possess it have this structure (Magnus' green salt may be considered a cis-compound) and pass into the trans-form. The problem as to whether the cis-stop is a sign of cis-structure or of the possibility of passing into the trans-form has not as yet been finally solved.

We must note that the cis-stops are fully reproduceable. Upon repeating the experiment with Peyronnet's salt, the new heating curve fully coincided with the first in temperature and in the nature of its stops (three effects). We may here point out that a number of different authors have given about the same temperature (approximately 950°) for the exothermic stop of

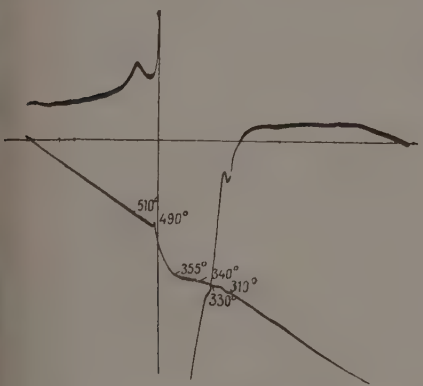

Fig. 3. Reiset's salt $\begin{matrix} Cl \\ NH_3 \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} NH_3 \\ Cl \end{matrix}$

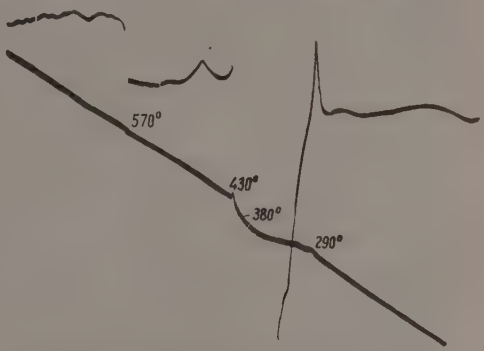

Fig. 4. Green Magnus' salt $\left[\begin{matrix} NH_3 \\ NH_3 \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} NH_3 \\ NH_3 \end{matrix}\right]\left[\begin{matrix} Cl \\ Cl \end{matrix}\!\!>\!Pt\!<\!\!\begin{matrix} Cl \\ Cl \end{matrix}\right]$

kaolin, which has been well studied. So far the only explanation for the three step-transitions from the cis- to the trans-form is that there are three intermediate substances formed, which are probably very unstable; we are conducting experiments to find out their properties.

Judging by the thermogram, Magnus' green salt isomerizes (passes from the cis-dimer into the trans-monomer) in one stage.

The heating curve method of experimentally determining the excess of free energy in cis-forms and polymers will be discussed separately in another paper.

The d e c o m p o s i t i o n s t o p s in Peyronnet's, Reiset's and Magnus' salts are very close to one another. This may be easily explained from the interpretation of the cis-form given above: it is the same compound that decomposes, viz., the chloride of Reiset's II base (trans). The latter salt plainly shows three stops 315, 330 and 340—355 ° which are evident even on the curve of the simple thermocouple record. In Magnus' and Peyronnet's salts the first two stops are hidden behind exothermic processes but the differential thermocouple brings them to light. The third stop is the same in all three compounds. The nature of the intermediate decomposition products is not yet clear.

It must be noted that directly after the cis-stop the compound decomposes. This may be explained as follows. Heat makes the bond within the lattice less and less stable until finally a point is attained (the cis-stop) after which regrouping becomes possible. During this regrouping free energy is evolved. But the bond in the newly-formed trans-compound is too unstable, and decomposition follows immediately. This scheme is probably compli-

cated by the fact that regrouping into the trans-form takes place partly at the expense of the complete decomposition (down to metallic Pt) of some of the complex compounds.

In ammonium chlorplatinate the first stage of decomposition begins at 215 and ends at 280°. This process uses up very little energy, so that the effect is registered only on the differential curve; possibly, the chlorine is freed at this point. The thermogram shows that at the point where decomposition begins the solid product is quite overheated (390°); after this the temperature falls to 380°. This second stage of decomposition to metallic platinum requires more energy.

The two stops for metallic platinum are exothermic and have been observed in Peyronnet's, Reiset's and Magnus' salts. One of them is at about 370—380, the other at about 490—510°. The latter is presentin ammonium chlorplatinate, while the former is lacking, which was only to be expected since the decomposition of the chlorplatinate ends at the temperature of the first stop and therefore platinum is immediately liberated in a more stable form.

After the complex compound is decomposed, the differential heating curve goes higher than before decomposition. This illustrates the greater heat conductivity of the metal. Reiset's salt was obtained from cis-compound (see above) and washed, after which the residue was handed over to V. G. Kuznetzov for X-ray investigation. The resulting roentgenogram showed rather diffuse lines of platinum; this means that the crystals present are of very small size, viz. between 10^{-6} and 10^{-7} cm. In that case the platinum exothermics are the formation of larger crystals at the expense of the smaller ones. This process is known to reduce the surface energy, the given exothermic corresponding to the amount of energy evolved. Thus, the energy excess in the platinum niello has been shown here experimentally. It is noteworthy that according to Cohen [8] explosive platinic metals also explode at the boiling point of sulphur (444°) and of mercury (360°). The transition temperature (I stage) determined by us, however, lies within 370—380°. The physico-chemical interpretation of the second stop at 510° is not yet clear.

Thus, we found a very interesting by-result for so ordinary a catalyzer as platinum niello which makes it possible to study catalyzers using the heating curves method.

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CHEMISTRY

INVESTIGATION OF THE COMPLEX COMPONENTS OF PLATINUM AND α- AND β-AMINOPYRIDINE

By A. M. RUBINSTEIN

(Communicated by N. S. Kurnakov, Member ot the Academy, 28.VI.1938)

Investigations of complex pyridine compounds of bivalent platinum made by many authors, beginning with Jorgensen's classical works, have established some very important regularities regarding the formation of complex compounds.

A study of complex pyridine compound of quadrivalent platinum, conducted by the author of this work under the leadership of prof. I. I. Cerniajev, showed the principle of transinfluence to be quite applicable in the study of these compounds and also established some new facts regarding complex pyridine compounds.

The complex compounds of platinum and α- and β-aminopyridine have not been studied at all as yet. Their study was necessary mainly in order to find out whether the complex compounds formed upon reaction with α- and β-aminopyridine would have closed cycles or not, and also to see how the position of the amino-group in the benzol nucleus would affect the formation of complex compounds.

An investigation of the action of α-aminopyridine on salts of bivalent platinum showed that: 1. α-aminopyridine and platinum form a stable complex compound. 2. When the complex compound forms there is no cycle formed. 3. Aminopyridine combines with platinum the nitrogen of its amino-group. 4. A number of complex compounds of α-aminopyridine and platinum have been produced which can be oxidized into complex compounds of quadrivalent platinum containing aminopyridine. 5. During the oxidation of platinum aminopyridine is haloidized, producing a di-$\beta\beta_1$-haloidsubstituted aminopyridine complex compound of quadrivalent platinum.

The action of α- and β-aminopyridine on the following compounds of bivalent platinum were studied: K_2PtCl_4, $K_2PtCl_3NO_2$ и $K_2Pt(NO_2)_4$.

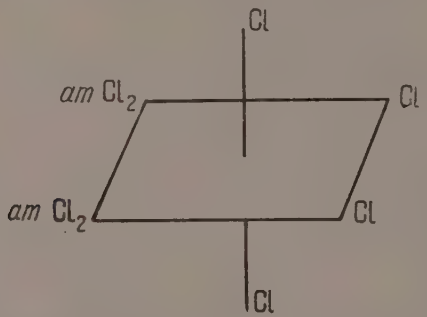
α-aminopyridine gave the following reactions with the salts of bivalent platinum:

$$K_2PtCl_4 + 2amPy \longrightarrow 2amPyCl_2Pt,$$
$$K_2PtCl_3NO_2 + 2amPy \longrightarrow 2amPyNO_2ClPt,$$
$$K_2Pt(NO_2)_4 + 2amPy \longrightarrow 2amPy(NO_2)_2Pt.$$

Action of α-aminopyridine on K_2PtCl_4. A weighed-portion of K_2PtCl_4 was dissolved in a small quantity of water and an aqueous solution of α-aminopyridine, containing exactly two molecules of α-amino-

pyridine was added. After standing a while a yellow and then a greenish precipitate appears. Analysis shows that pure salt $2amPyCl_2Pt$ precipitates at first, and then a greenish (and sometimes even black) precipitate of a high platinum content begins to fall out. The analysis showed: weighed-portion 0.1528, after drying 0.1505; weight of platinum 0.0650, per cent platinum in the dry weighed-portion is 43.19. According to theory, the content of platinum in $2amPyCl_2Pt$ is 42.99 per cent.

The reaction between K_2PtCl_4 and α-aminopyridine should be conducted in the cold, otherwise α-aminopyridine becomes resined and a black precipitate of a variable composition is produced.



When K_2PtCl_4 reacts with one molecule of α-aminopyridine the product may have various compositions, and we did not succeed in obtaining a strictly individual substance.

The oxidation of $2amPyCl_2Pt$ with gaseous chlorine was of special interest. A study of the properties of free α-aminopyridine showed that free chlorine reacts with it giving β- and $\beta 3_1$-haloidsubstituted aminopyridine. It was necessary to find out how the α-aminopyridine in the complex compound would be affected if the platinum were oxidized.

Water was made turbid by adding a weighed-portion of $2amPyCl_2Pt$ and acted upon with gaseous chlorine. This made the precipitate gradually turn red. Oxidation is considered complete when analyses for platinum give a constant result.

Analysis of the substance produced when oxidized with chlorine gave the following results:

for platinum: weighed-portion 0.1010, weight of Pt 0.0294, per cent Pt=29.11 for nitrogen: weighed-portion 0.0808, volume 6.3 cm^3, temperature 24°, pressure 750 mm, per cent 8.57. Ratio of nitrogen to platinum is 4.1. For chlorine: weighed-portion 0.1250, weight of argentic chloride 0.1936, per cent of Cl=38.32. Ratio of chlorine to platinum is 7.29. The low percentage of chlorine is due to the fact that chlorine was determined by calcining with soda and not after the methods of organic analysis.

This analysis shows that when $2amPyCl_2Pt$ is oxidized with chlorine two reactions take place: one is the oxidation of bivalent platinum into quadrivalent, and the other—the haloidization of aminopyridine producing the following compound (see the figure).

According to theory: platinum = 29.27 per cent; chlorine = 42.86 per cent; nitrogen = 8.39 per cent.

We also studied the action of concentrated sulphuric acid and hydrogen peroxide on $2amPyCl_2Pt$.

Precipitate of $2amPyCl_2Pt$ dissolves in concentrated sulphuric acid, giving a brown liquid and liberating sulphur dioxide. If water is added to this solution a yellow precipitate appears (a solution of the salt in sulphuric

acid is poured into cold water; an amorphous yellow precipitate appears which then blackens and after washing with water turns brown).

Analysis of this substance showed:
weighed-portion 0.0900, Pt 0.0434, per cent Pt=48.32
weighed-portion 0.1270, Pt 0.614, per cent Pt=48.35
weighed-portion 0.1211, Pt 0.0594, per cent Pt=49.05
weighed-portion 0.0971, Pt 0.0454, per cent Pt=46.76

In order to find out why the precipitate turns brown when washed with water we often washed it only with anhydrous alcohol. In this case the precipitate had a yellowish-green colour.

Analysis showed:
weighed-portion 0.1125, Pt 0.0543, per cent Pt=49.4
weighed-portion 0.0959, Pt 0.0462, per cent Pt=48.2

After boiling in water the substance produced during oxidation with sulphuric acid gives only a slight turbidness with $BaCl_2$ and $AgNO_3$.

As the analyses show, strong sulphuric acid not only oxidizes the complex compound, but also partly destroys it, as a result of which the substance is of more or less indefinite composition and contains more platinum.

To find out the structure of our complex compound $2amPyCl_2Pt$ we used N. S. Kurnakov's reaction of treating complex compounds of platinum with thiourea.

A weighed-portion of $2amPyCl_2Pt$ was treated with solution of thiourea in excess, and heated (very gently) until all the $2amPyCl_2Pt$ was dissolved. The solution was yellow in colour. The solution was additioned with potassium oxalate, upon which appears a crystalline precipitate of creamy-white colour.

Analysis showed:
weighed-portion 0.0964, after drying 0.0931, loss in drying 0.0033, per cent in the dry weighed-portion Pt=33.08, per cent water 3.42. Weighed-portion 0.1066, after drying 0.1039, weight of Pt=0.0344, per cent of Pt=33.12, per cent water 2.54

Analysis for sulphur gave:
weighed-portion 0.0737, weight $BaSO_4$ 0.1206, per cent S=22.47

The analysis shows that when $2amPyCl_2Pt$ is treated with potassium oxalate the following compound results:

$$\left[Pt\,4CS\begin{matrix}NH_2\\NH_2\end{matrix}\right]C_2O_4H_2O.$$

Since the action of thiourea gives a full substitution for the latter in the inner sphere we should conclude that $2amPyCl_2Pt$ is of cis-structure.

A study of the electrical conductivity of this compound confirmed the formula we accepted for the compound formed in reaction of α-aminopyridine and K_2PtCl_4:

Diluted 10 000 times

t min	30	40	50	60	80
μt	15.8	17.9	24.5	25.6	32.95

This salt is very slightly soluble: even diluted 10 000 times it does not dissolve completely. The conductivity was determined in the presence of the precipitate.

The Action of α-aminopyridine on $K_2PtCl_3NO_2$. This reaction proceeds similarly to the action of α-aminopyridine on K_2PtCl_4 studied by us.

α-aminopyridine does not react immediately with $K_2PtCl_3NO_2$. After a while a yellow precipitate appears. Analysis showed that this precipitate has the following composition: $2amPyClNO_2Pt$.

Analysis for platinum showed:

weighed-portion 0.0987, after drying 0.0945, per cent water lost 4.25, weight Pt 0.0398, per cent in the dry weighed-portion Pt=42.12

Analysis for NO_2:

weighed-portion dry 0.1233, volume of N=3.1 cm³, temperature 20°, pressure 751.1 mm, per cent N=3.09

Analysis for nitrogen:

weighed-portion dry 0.1193; volume of N=16.1 cm³, pressure 754.8 mm, temperature 20°, per cent N=15.26

According to theory: Pt=42.01 per cent; N from NO_2=3.01 per cent; total N=15.06 per cent.

Electrical conductivity

t min	20	30	40	50	after 48 hours
μt	9.1	15.2	17.8	24.78	85.9

The study of the reaction with gaseous chlorine led us to the conclusion that in this case also alongside with oxidizing of platinum there takes place haloidizing of aminopyridine as well.

Gaseous chlorine is passed through a turbid aqueous solution of $2amPyClNO_2Pt$. After 6—8 hours the precipitate turns red.

Analysis of the product of oxidation showed:

weighed-portion 0.0811, dry 0.0751 (when dried the precipitate turns brown), weight Pt=0.0218, per cent in the dry weighed-portion Pt=29.03

Analysis for nitrogen:

weighed-portion dry 0.0570, volume N=5.5 cm³, temperature 19.5°, pressure 751.6 mm, per cent N=10.88

Analysis for chlorine:

weighed-portion 0.0808, weight of argentic chloride 0.1078; per cent Cl=33.01 (the chlorine content is low because it was determined by calcining with soda, and not after the method usually adopted in organic analysis)

According to theory, $2amPyClNO_2Pt$ should contain: Pt=28.82 per cent; N=10.34 per cent; Cl=36.63 per cent.

Oxidation is much more difficult a process in this case, than in case of $2amPyCl_2Pt$.

The Action of α-aminopyridine on $K_2Pt(NO_2)_4$. In this case we get a pale yellow precipitate of a composition analogous to those obtained when aminopyridine reacted with K_2PtCl_4 and $K_2PtCl_3NO_2$, viz., $2amPy(NO_2)_2Pt$. Gaseous chlorine does not oxidize this compound.

Electrical conductivity of $2amPy(NO_2)_2Pt$

t min	10	20	30	40	after 24 hours
μt	0.85	2.38	2.58	2.58	5.3

The results of the action of β-aminopyridine on the salts of bivalent platinum and the action of α-aminopyridine on palladium salts will be reported in the next paper.

The investigation is being continued.

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CHEMISTRY

A SYNTHESIS OF 10-ALKYL-DERIVATIVES OF 9-METHYL -1.2-BENZANTHRACENE

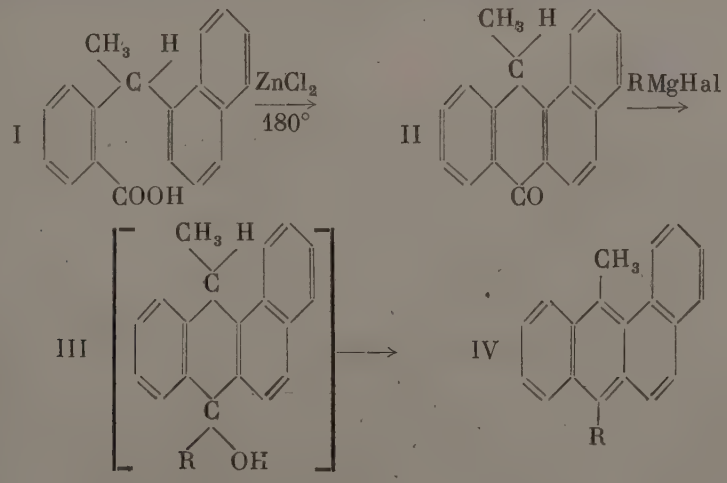
By B. M. MIKHAILOV and N. G. ČERNOVA

(Communicated by N. D. Zelinsky, Member of the Academy, 28.VI.1938)

The researches of Cook and Fieser have shown the alkyl derivatives of 1.2-benzanthracene substituted in the positions 9 and 10, namely 9-methyl-(1) and 10-methyl-1.2-benzanthracene (2), to possess a strong cancerogenic action.

It was of some interest to obtain 9.10-dialkyl derivatives of 1.2-benzanthracene and test them for their cancerogenic effect.

We have prepared for this end 9.10-dimethyl-, 9-methyl-10-ethyl-, 9-methyl-10-n-propyl- and 9-methyl-10-n-butyl-1.2-benzanthracenes according to the following method: 2-(α-1-naphthyl-ethyl)-benzoic acid (1) (I) was cyclized by means of anhydrous zinc chloride to give 9-methyl-1.2-benzanthrone-10 (II) with a yield of 70% of the theoretical. The corresponding dialkyl-derivatives of 1.2-benzanthracene (IV) were obtained by the action of alkyl-magnesium-halides on methyl-benzanthrone, the dialkyl-dihydro-benzanthranols (III) formed as intermediate products being almost completely dehydrated in the course of the Grignard reaction:



$R = CH_3,\ C_2H_5,\ n-C_3H_7,\ n-C_4H_9.$

When our work was almost concluded, there appeared papers by Bachman and Chemerda[3] and Newman[4] who prepared 9.10-dimethyl-1.2-benzanthracene. Bachman and Chemerda obtained this hydrocarbon by the action of methyl-magnesium-iodide on 1.2-benzanthraquinone, while Newman did it in the same way as the authors of this paper, with the only difference that he cyclized 2-(α-1-naphthyl-ethyl)-benzoic acid in another way and did not isolate 9-methyl-1.2-benzanthrone-10 in a pure state.

Experimental

(The analyses were performed by A. D. Tchinaeva and A. N. Blokhina)

9-methyl-1.2-benzanthrone. 12 g of 2-(α-1-naphthyl-ethyl)-benzoic acid were heated at 180° with 35 g of anhydrous zinc chloride for one hour. The cooled reaction mixture was ground and then treated with dilute hydrochloric acid. The residue was dissolved in 200 ml of ether, the solution extracted with a dilute soda solution, filtered and then the ether removed. The residue was crystallized from aqueous acetone. 7.89 g of the material, m. p. 105—106.4°, was obtained (yield 70%). A part of methyl-benzanthrone was recrystallized once more from acetone; colourless plates, m. p. 106.4—107.2°.

Analysis. 3.763 mg taken; 12.206 mg CO_2; 1.890 mg H_2O. Found: C=88.49%; H=5.61% ($C_{19}H_{14}O$ requires C=88.34%; H=5.46%).

9-methyl-10-alkyl-1.2-benzanthracenes. 1.5 g of 9-methyl-1.2-benzanthrone-10 in 100 ml of dry benzene were gradually stirred into a Grignard solution obtained from 1.4 g of magnesium (10 mols), the corresponding alkyl halide and 100 ml of ether. A green-coloured solution was refluxed for 3 hours. After that the reaction mixture was decomposed with a solution of ammonium chloride and then the ether-benzene layer evaporated. When preparing 9.10-dimethyl-derivative, the crystals of the latter deposited directly from the solution evaporated to a small volume; the isolation of other hydrocarbons was effected in the form of picrates.

9.10-dimethyl-1.2-benzanthracene. 0.58 g of the crystals, m. p. 118—121°, were isolated from the ether-benzene solution (39% of theoretical). The hydrocarbon crystallized from ethanol in plates with yellowish tint, m. p. 122—123°. Monopicrate—long black needles, m. p. 112.2—113.2°.

9-methyl-10-ethyl-1.2-benzanthracene. The ether-benzene layer, obtained after the Grignard reaction, was evaporated to dryness, the residue dissolved in dry ethanol and treated with picric acid. The dipicrate deposited (2.53 g, m. p. 111—113°) was twice recrystallized from dry ethanol. The dipicrate crystallizes in small carmine-red needles, m. p. 116—116.8°.

Analysis. 4.900 mg taken; 0.504 ml N_2 (25°, 747 mm). Found: N=11.58% ($C_{33}H_{24}O_{14}N_6$ requires N=11.54%).

A hydrocarbon was isolated in the form of plates with yellowich tint (from alcohol), m. p. 70—71.5°, on decomposition of the picrates.

Analysis. 3.250 mg taken; 11.110 mg CO_2; 1.890 mg H_2O. Found: C=93.23%; H=6.99% ($C_{21}H_{18}$ requires: C=93.23%; H=6.71%).

9-methyl-10-n-propyl-1.2-benzanthracene. A hydrocarbon was isolated similarly with the preceding one. The dipicrate obtained crystallized from dry alcohol in red needles, m. p. 95—98°.

Analysis. 6.282 mg taken; 0.629 mg N_2 (23°,743 mm). Found: N=11.28% ($C_{34}H_{26}O_{14}N_6$ requires N=11.32%).

A hydrocarbon was isolated from the picrate, which crystallized in the form of small light-green needles, m. p. 99—101°.

Analysis. 3.015 mg taken; 10.248 mg CO_2; 1.984 mg H_2O. Found: C=92.70%; H=7.03% ($C_{22}H_{20}$ requires: C=92.91%; H=7.09%).

9-methyl-10-n-butyl-1.2-benzanthracene. 2.12 g of dipicrate, m. p. 102—103.5°, were recovered on treatment of the residue obtained from Grignard reaction. When recrystallized from dry alcohol the dipicrate was obtained in form of red needles, m. p. 104.6—105.8°.

Analysis. 5.363 mg taken; 0.549 mg N_2 (24°, 743 mm). Found: N=11.2% ($C_{35}H_{28}O_{14}N_6$ requires N=11.5%).

The hydrocarbon recovered from picrate crystallized from dry alcohol in small plates with light-yellowish tint, m. p. 71—72°. The yield of hydrocarbon was 30% of the theory.

Analysis. 3.063 mg taken; 10.378 mg CO_2; 2.077 mg H_2O. Found: C=92.48%; H=7.59% ($C_{23}H_{22}$ requires C=92.57%; H=7.43%).

Summary

1) 9-methyl-1.2-benzanthrone-10 has been obtained by cyclization of of 2-(α-1-naphthyl-ethyl)-benzoic acid with zinc chloride.

2) 9.10-dimethyl-,9-methyl-10-ethyl-,9-methyl-10-n-propyl- and 9-methyl-10-n-butyl-1.2-benzanthracene have been obtained by a treatment of 9-methyl-1.2-benzanthrone with alkyl magnesium halides.

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CHEMISTRY

ON THE REACTION FOR DISTINCTION OF LEVULOSE FROM GLUCOSE

By O. M. CHERNTSOV

(Communicated by M. A. Iljinsky, Honorary Member of the Academy, 27.VI.1938)

E. V. Zmachinski has recently described a new reaction for distinguishing levulose from glucose (1). This reaction consists in heating the sugar to be investigated in glycerine with a small amount of sulphur and 1—2 drops of lead acetate solution for a short time. As the author reports, upon heating the liquid in the test tube containing levulose becomes black, while that in the tube with glucose remains unchanged.

These observations induced the author to suggest the above test as a means to demonstrate the difference between levulose and glucose (or such sugars as saccharose, maltose and lactose, which react like glucose) and even to prefer it to the well-known reaction of Seliwanoff(2).

Being interested in this question as connected with one of my studies, I have tried the reaction suggested by Zmachinski, but in my tests I failed to confirm the observations of this author. The following substances were chosen as objects of tests: levulose, glucose, galactose, maltose, lactose and saccharose (all the sugars mentioned above, except saccharose, were produced by Kahlbaum or De Haen). Strictly following the indications given by Zmachinski, I was able to find that the effect of the reaction (a characteristic blackening on account of PbS formation) took place simultaneously and was found to have the same intensity for levulose as for the other monosaccharides mentioned above, while in the case of disaccharides as should be expected it set in much later and proceeded slower. It is necessary to note that in all the cases the reaction requires a heating slightly above the temperature of the melting point of sulphur.

Zmachinski explains the results obtained by the presence of the CHOH. .CO-group in levulose, which group secures the reaction with sulphur. The course of this reaction is to Zmachinski's opinion similar to the reaction of sulphur with benzoin, which he had previously investigated (3).

Without entering into a detailed discussion as to the possibility of a full analogy between these essentially different cases, I must mention only that even a priori one scarcely may expect sharp differences in the reactivating influence exerted on the secondary hydroxyl groups by α-oxyketones or α-oxyaldehydes. This statement is confirmed by the described results of my observations made on different sugars. At the same time I became experi-

mentally convinced that the substances lacking the carbonyl group, as mannite and dulcite, do not react with sulphur under the same conditions.

Summary. The reaction for distinguishing levulose from glucose (respectively from other sugars) suggested by Zmachinski is no specific reaction for levulose, since it proceeds as easily with levulose as with aldoses, and only imperceptibly slower with disaccharides.

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GEOCHEMISTRY

THE PAVLODAR STONY METEORITE

By E. L. KRINOV

(Communicated by W. I. Vernadsky, Member of the Academy, 24.VI.1938)

Four fragments of a stony meteorite, which had fallen in May 23rd, 1933, at Pavlodar, Kasakhstan Socialist Republic, were added to the meteorite collection of the Academy of Sciences of the USSR in June of the current year.

On the fall and recovery of this meteorite the following information is available, which has been obtained by the Meteorite Committee from the East Kazakhstan Regional Museum (Semipalatinsk) in a letter of June 7th, 1938, and at a somewhat earlier date by B. E. Begishev.

The meteorite fell «with a loud crash» at Pavlodar, on May 23rd, 1933, at 1.40 p. m.* at a distance of 1 m from the citizen Pokidov who was crossing the square near the City Council. On striking the ground, the meteorite penetrated into the sand and was still warm to the touch when picked up by Pokidov. Immediately after the fall, Pokidov brought the meteorite to the office of the Election Committee of the 5th District, and there the meteorite was cracked, whereupon the larger piece remained with the Chairman of the aforesaid Committee while four small fragments were turned over by Pokidov to the East Kazakhstan Regional Museum. The latter in its turn sent these fragments to the Meteorite Committee.

The original weight of the meteorite was 120 g and its shape was rectangular measuring 6.5 by 3.5 cm; the side which touched the ground was somewhat convex.

It was rumored that at the time when the meteorite had fallen, about 4 m away from the place of its fall, one more fragment of the meteorite was picked up by another Kazakh (whose name and surname are unknown).

The weight of the fragments (Fig. 1) received by the Meteorite Committee from the East-Kazakhstan Museum is as follows:

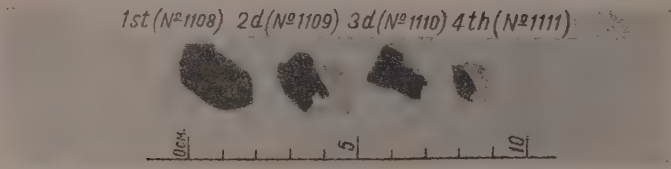
First fragment,	reg. No	1108—	10.16 g
Second fragment	» No	1109—	7.20 »
Third fragment	» No	1110—	3.15 »
Fourth fragment	» No	1111—	1.95 »
			22.46 g

All these fragments have retained parts of the crust, the largest of them No 1108 having crust on both sides. The first three fragments fit well in the

* What time should be understood—is not indicated.

cracks, and this enables one to reconstruct approximately the original shape of the meteorite. In addition ot the measurements indicated above, judging by the fragments, the thickness of the meteorite may be figured equal, approximately, to 2 cm.

The meteorite may evidently be classed as a white chondrite. When examined through a magnifying glass ($\times$ 10) fractures (still perfectly fresh), darker bluish-smoky chondrules can be detected among the considerably lighter remaining mass of the meteorite. Besides, there are visible numerous droplike minute inclusions of metal*.



On one side of the meteorite, apparently the one in front with regard to the direction of the flight, the crust is considerably thinner (not more than 0.2 mm), smooth and dull of dark grey (nearly black) colour. On the opposite side, which is convex (see above), evidently the back side, the crust is much more rugged, resembling the caked surface of slag of dark grey smoky-tinted colour with a faint dull (waxen) luster, and is about 0.6 mm thick.

The described meteorite is the second one that fell and was found this year and is the ninetieth on the list of meteorites found in the USSR. Under the same name «Pavlodar» there is registered in Prior's catalogue another meteorite—a pallasite which had been found in 1885 and otherwise known both as Yamyshev and Semipalatinsk. However, on the list of meteorites in the USSR this meteorite has been entered under the name of Yamyshev.

Meteorite Committee.
Academy of Sciences of the USSR.

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* According to the general impression. this meteorite, when viewed from the point of its inner mass, presents a complete analogy with the meteorite Lavrentyevka (C. R. Acad. Sci. URSS, XX, № 4, 1938).

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GEOLOGY

ON THE FORAMINIFERA FROM THE TRANSITIONAL BEDS BETWEEN THE DEVONIAN AND THE CARBONIFEROUS (ETROEUNGT ZONE) OF KAZAKHSTAN, SOUTH URALS AND SAMARSKAYA LUKA

By V. N. KRESTOVNIKOV and D. M. RAUSER-CHERNOUSOVA

(Communicated by A. D. Arkhangelsky, Member of the Academy, 13.VI.1938)

In the course of the preliminary study of the material collected by the Kazakhstan complex expedition of the Academy of Sciences in 1936—1937, interesting Endothyra and some other Foraminifera were detected in the lowermost parts of the Lower Carboniferous.

According to D. V. Nalivkin's usually adopted stratigraphical scheme, the following deposits may be discriminated among the lower horizons of the Lower Carboniferous in Central Kazakhstan; the Upper Turnaisian deposits—Russakov beds and the Lower Turnaisian deposits—Kassin beds. They are underlain by Upper Devonian deposits referred to the Famenian stage. Among the latter Upper Meister or Sulzifera beds and the Lower Meister or Calcaratus beds are distinguished. The calcareous section being uninterrupted from the Upper Devonian to the Visean stage, it would be natural to expect the presence of transitional beds from the Devonian to the Carboniferous in Kazakhstan too. In fact, beds analogous to the Etroeungt or Pilton beds of Devonshire have been distinguished by D. V. Nalivkin above the Upper Meister beds. These very beds have been found to be relatively the richest in Foraminifera.

The Brachiopoda of these beds in Kazakhstan are distinguished by their mixed character and contain both typical Upper Devonian and Lower Carboniferous forms. The finding of Foraminifera in these deposits of Kazakhstan permitted of a more accurate determination of their age which the present authors made an attempt to effect.

The Foraminifera, particularly the Endothyra of the Devonian and Turnaisian deposits, have been unsifficiently studied. Certain Foraminifera found in some sections of the South Urals and Samarskaya Luka already studied have been used for comparison. Foraminifera quite identical to those from Kazakhstan have been found in the intermediate zones between the Devonian and the Carboniferous (the Etroeungt zone) of the South Urals and the Samarskaya Luka. According to V. N. Krestovnikov, this complex of Foraminifera is most distinctly manifested in Central Kazahstan in the sections made along the Djilandy river and according to N. V. Litvinovich—in the neighbourhood of the lake Kos-Kul. The fauna of these two sections is identical and consists of two genera of Endothyra accompanied by some other

Foraminifera with rudimental septa and a very coarse partition. One of the Endothyra (*Endothyra* sp. № 1) is of a very primitive habit, consists usually of 2—2$^1/_2$ more or less symmetrical volutions, possesses a coarse-grained partition, probably with agglutinated particles and very short and sparce septa. A form closely approaching the latter has been observed in the Sulzifera beds (lake Kobeituz), an identical form has been found in the Etroeungt beds of the South Urals and at Samarskaya Luka, while closely approaching forms are met with in the Lower Turnaisian deposits of the Urals.

Another genus, *Endothyra* sp. № 2, is a more differentiated form distinguished by its considerable size, its external volutions being incompletely involute, and by a large number of septa (10—12 in the last volution).

The most characteristical feature of this genus is the presence of an additional endoskeleton forming two spiral strings along the base of the volution, limiting the aperture from two sides like the chomata of Fusulinides. Quite identical specimens of this genus have been encountered aside from Kazakhstan also in the South Urals and Samarskaya Luka in the Etroeungt beds, but they have been detected neither in the over nor in the underlying beds.

Somewhat different is the complex of the third location of these Endothyra, namely that from the lake Kobeytuz near the Eremena-Tau mountains. Alongside of *Endothyra* sp. № 1, *Endothyra* sp. № 3 has been encountered here, closely approaching *Endothyra* sp. № 2, but differing from the latter by its larger size, a greater number of septa and (what is most essential) by a greater symmetry and involution of volutions. So far this species is known only from the uppermost layers of the Upper Devonian of the Samarskaya Luka.

The three above shown Endothyra beds in Kazakhstan are characterized as follows with regard to their mode of occurrence and the fauna of Brachiopoda they contain.

The first stratum is located south-eastward from the Ulu-Tau mountains on the Djilandy river (Kokpekty) westwards from the mountain Ak-Djal. Here thick beds both of dark-grey bituminous limestones occasionally recrystallized and of dolomites are repeatedly exposed along the left-hand bank of the river. In the lower horizons of these beds the following fauna has been found as determined by N. V. Litvinovich: *Productus* cf. *praelongus* Sow. var. nov., *Productus gorsky* Nal., *Spirifer* ex gr. *verronensis* Swall., *Syringothyris* typus Winch., *Syringothyris distans* Sow., *Dielasma arkansanum* Well., *Schellwienella panumbona* Well., *Orthotetes keokuk* Hall.

The second stratum is located north-eastward from the Ulu-Tau mountains, 10 km north-eastwards from lake Kos-Kul. Here Endothyra are encountered in dark-grey limestone, containing according to N. V. Litvinovich: *Productus praelongus* Sow., *Productus* cf. *kassini* Nal., *Spirifer archiaci* Murch., *S. semibugensis* Nal., *S. disjunctus* Sow., *S. legrandensis* Hall.

The third stratum of Foraminifera in Central Kazakhstan is referred to the section of lake Kobeituz near the Eremen-Tau mountains where *Endothyra* sp. № 1 and *Endothyra* sp. № 3 have been determined in grey-brownish silicified limestone with corals and stromatopors. A. M. Simorin has determined there following Brachiopoda: *Reticularia coeperensis* Sow., *Spirifer sibiricus* lib., *Tylothyris laminosa* M. Coy, *Productus concentricus* How., *Dielasma* sp., *Athyris angelica* Hall., *Chonetes* sp.

In all three instances the transitional character of the fauna is clearly manifested in the Brachiopoda from the Kazakhstan beds under investigation; they present a mixture of such typical Upper Devonian forms as *Spirifer archiaci*, *S. disjunctus*, *S. semibugensis*, *Arthyris angelica* and Turnaisian forms as, for instance, *Productus kassini*, *Spirifer sibiricus*, *Tylothyris lami-*

nosa, *Orthotetes keokuk* etc. It should be noted that such a mixed complex of Brachiopoda is common to the Etroeungt beds in other districts too. Thus, in the South Urals the Devonian *Productus subaculeatus*, *Althyris* sp., *Orthis bistriata* and Lower Carboniferous *Tylothyris laminosa*, *Spirifer tornacensis* etc. are also encountered together in these beds.

In the Etroeungt beds of Novaja Zemlya whose age has been determined by D. V. Nalivkin from a study of Brachiopoda and by I. I. Gorsky([1]) from a study of corals, Devonian forms are also established together with Lower Carboniferous.

As stated above, a complex of Foraminifera fully identical to that studied in Kazakhstan, has been encountered in the South Urals and at Samarskaya Luka.

In the South Urals, along the Zighan river, *Endothyra* sp. № 1 and *Endothyra* sp. № 2 have been discovered together with microfauna of the Etroeungt type in beds referred to the lower horizons of the Etroeungt bed section reported from the Zighan river ([2]).

At Samarskaya Luka species identical to those of Kazakhstan have been encountered in two bands in the section of the bore-hole № 401 located near the town of Syzran. Here below the Turnaisian deposits at a depth of 1046-1069 m light-grey and greenish limestones are located with bands of bluish-grey calcareous clays and marls and with minute fauna of the Malevko-Murayevna bed type, *Rhynchonella*, *Chonetes*, *Athyris* (analogues of the Upa and Malevko-Murayevna beds). Lower at a depth of 1073—1078 m *Endothyra* sp. № 1 and *Endothyra* sp. № 2 have been determined from light-grey heterogeneous limestones (evidently in part dolomite limestones) with irregularly twisted black argillaceous bands and widely-spaced small caverns whose walls are covered with small calcite crystals.

When compared with the section of the Moscow basin the latter beds may be referred to the Khovansky beds of the Moscow basin (lower portion of the Etroeungt beds).

Still lower at a depth of 1114—1120 m abundant *Endothyra* sp. № 3 identical to that of Kazakhstan have been determined in light-grey heterogeneous dolomite limestones showing imprints of *Spirofer* ex gr. *archiaci* Murch. and evidently belonging to the Famenian stage.

From all the above said it may be inferred that the Endothyra under investigation are in fact characteristic of a certain stratigraphic horizon of Kazakhstan, the Urals and Samarskaya Luka, which may be compared with Etroeungt zone, the lowermost portion of the Lower Carboniferous. The beds with Endothyra of the lake Kobeytuz section probably belong to the older portion of this zone, inasmuch as the Endothyra of these beds have been encountered at the Samarskaya Luka stratigraphically lower than the Endothyra of the more western sections of Kazakhstan.

In conclusion it will be indicated that the Endothyra under investigation are of high morphological interest owing to the peculiar mixture of features inherent to the Devonian, Turnaisian and Visean-Endothyra; the presence of an additional basal endoskeleton in these Endothyra is of particular interest as throwing light on the phylogeny of Fusulinides, whose ancestral form is to be sought in this very group of Endothyra.

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GENETICS

THE RÔLE OF AMPHIDIPLOIDS AND OTHER BALANCED TYPES IN CROSSES BETWEEN WIDELY SEPARATED FORMS

By O. N. SOROKINA

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The sterility of the hybrids between *Aegilops* and *Triticum* is very high. We have produced about a hundred different combinations between *Aegilops* and wheat, and in the majority of cases they were sterile in F_1.

Backcrosses of the first generation with the parents give a very slight effect which on the average leads to 0.26 per cent of successful pollinations. In studying the segregation of the partly fertile hybrids we have met reversion to the parental type, and particularly almost always to the *Aegilops* type, the latter genus being usually the mother. In some cases hybrids of intermediate type arose; they were constant from the second generation, i. e. represented amphidiploids, while in other cases the intermediate hybrids segregated with regard to some cheracters and possessed chromosome numbers higher than those in parents.

Backcrosses produced in rare cases fully constant hybrids as a result of autosyndesis taking place in them, and in the late generations from the cross of the 28-chromosome *Aegilops* with the hard wheat forms arose which were similar to *Tr. vulgare* and had 42 chromosomes.

There are altogether 5 amphidiploids which arose in F_2, probably due to non-reduction and to splitting of all the univalents in the meiosis of the F_1; in the further discussion, however, we shall concentrate attention only upon two of them, viz., *Ae. longissima* ($n=7$)$\times$*Tr. durum* ($n=14$) possessing $2n=42$, and *Ae. ventricosa* ($n=14$)$\times$*Tr. durum* ($n=14$) with $2n=56$, and upon one autosyndetic form. The autosyndetic form (*Ae. ventricosa* $\times$ $\times$*Tr. dicoccum*)$\times$*Tr. dicoccum* was obtained in the following manner; the 28-chromosome F_1 *Ae. ventricosa* ($n=14$)$\times$*Tr. dicoccum* ($n=14$) was crossed with *Tr. dicoccum*. One plant which gave rise to the constant 42-chromosome form was obtained from this backcross. The chromosomes of *Tr. dicoccum* evidently conjugated with each other while the chromosomes of the two genoms of *ventricosa* were also able to form pairs. This led to formation of 21-chromosome gametes and to production of a balanced and wholly constant form possessing 42 chromosomes.

It is known from works by G. D. Karpechenko ([1], [2]) that crossability of amphidiploids and tetraploids with other species is changed in contrast with the crossability within the species.

The crossability of the hybrid balanced forms with soft wheats as compared with the crossability of their components and of the F_1 with the same species of wheat was in our experiments as follows:

Ae. longissima×*Tr. vulgare*	0
F_1 (*Ae. longissima*×*Tr. durum*)×*Tr. vulgare*	0
The amphidiploid » × » × »	35.0
F_1 (*Ae. longissima*×*Tr. durum*)×*Tr. durum*	0.8
The amphidiploid » × » × »	17.0
Ae. ventricosa×*Tr. vulgare*	0
F_1 (*Ae. ventricosa*×*Tr. durum*)×*Tr. vulgare*	0.9
The amphidiploid» × » × »	40.7
F_1 (*Ae. ventricosa*×*Tr. durum*)×*Tr. durum*	0.3
The amphidiploid » × » × »	23.0
(*Ae. ventricosa*×*Tr. dicoccum*×*dicoccum*)×*Tr. vulgare*	53.0

In view of such a high crossability of these forms with wheat we obtained the possibility of employing them on a large scale in our experiments for the study of the combination of characters in crosses between far distant forms and at the same time the possibility of studying the value of the polyploid itself for plant breeding (Fig. 1). From the plant breeding viewpoint an amphidiploid, for example *Ae. longissima*×*Tr. durum*, attracts attention by possessing large grains which exceed in size those of the original parental forms, and the hybrid *Ae. ventricosa*×*Tr. dicoccum*×*dicoccum* is distinguished through its exceptional resistance to all the three species of rust while it may compete in this respect with *Tr. Timopheevi*. Thanks to high crossability with *Tr. vulgare* and significant fertility in F_1 and F_2, hybridization of this autosyndetic form with soft wheat may, perhaps, be more successful than crosses with the immune wheat, *Tr. Timopheevi*, itself.

Fig. 1. Hybrids of balanced forms with soft wheat: *a*—autosyndetic form (*Aegilops ventricosa*×*Tr. dicoccum*) ×*Tr. dicoccum*, 2*n*=42; *b*—*Tr. vulgare lutescens* 062; *c*—F_1, *d*—amphidiploid *Ae. ventricosa*×*Tr. durum*, 2*n*=56; *e*—F_1, amphidiploid *Ae. ventricosa*×*Tr. durum* with soft wheat 062; *f*—amphidiploid *Ae. longissima*×*Tr. durum*, 2*n*=42; *g*—F_1, hybrid of amphidiploid *Ae. longissima*×*Tr. durum* with soft wheat.

While studying elimination and recombination of chromosomes in hybridization of distant forms, when one turns from the study of the production of forms through free segregation to the production of balanced forms of various grades of intermediacy and resorts to backcrosses, gametes of the amphidiploid replace the F_1 gametes in those cases when one largely reckons upon the union with a non-reduced F_1 gamete in the backcross. The percentage of successful backcrosses being low (as shown above) crosses with amphidiploids and with other constant hybrids, the composition of whose gametes is known, are of great advantage.

As may be seen from the figures, the crossability of the amphidiploids and of the autosyndetic form is rather high, but the hybrids behave further quite differently. In the first case we have [(*Ae. longissima*×*Tr. durum*)× ×*Tr. vulgare*] a 21-chromosome gamete of the amphidiploid and the 21-chromosome gamete of *vulgare*, in the second case a 28-chromosome gamete *Ae. ventricosa*×*Tr. durum* and a 21-chromosome gamete of *vulgare*, and in the third case a 21-chromosome gamete *Ae. ventricosa*×*Tr. dicoccum* (where the 7 chromosomes belong to *ventricosa*, and 14 to *dicoccum*) and 21-chromosome gamete of *vulgare*.

The behaviour of these hybrids is the following one: in meiosis at the I

metaphase in F_1 (*Ae. longissima*×*Tr. durum*)×*Tr. vulgare* there are 14 bivalents and 14 univalents. Fertility in F_1 is very low, the number of kernels being 0—3 per spike and 0—6 per plant; segregation in F_2 is rather profound without occurrence of *Aegilops* types; fertility in F_2 is also wery low.

In the cross of the amphidiploid (*Ae. ventricosa*×*Tr. durum*)×*Tr. vulgare* we have met an unexpectedly high fertility: there were 21—32 kernels per spike while a plant bore as much as 3000 kernels, the percentage of fertility attaining thus 65. The meiosis in these hybrids being not studied yet we have nevertheless reasons to think that full or nearly full conjugation should occur here since investigation of somatic cells showed that F_2 plants possess in the majority of cases 42 chromosomes; moreover, the case is also analogous to the cross (*Ae. ventricosa*×*Tr. dicoccum*×*dicoccum*)×*Tr. vulgare*. At the I metaphase in the F_1 of the last mentioned cross we have found 21 bivalent; sometimes there were 20 and, on rare occasions, even 19 of them; its fertility is equal to 65 per cent. A similar cross (*Tr. ventricosa*×*dicoccum*×*dicoccum*)×*spelta* had 21 bivalent in meiosis of F_1, high fertility in F_1 (up to 86 per cent) and a rather superficial segregation in F_2.

The differences in the behaviour of the hybrid forms described above depend evidently upon differences in homology of the genoms of the *Aegilops* components. The chromosome set of *Ae. longissima* is evidently less homologous to the seven chromosomes of *vulgare* than the set of *Ae. ventricosa* and one of the two *ventricosa* genoms is highly homologous to the *vulgare* genom. Unfortunately, direct crosses of *Ae. ventricosa* with the soft wheat were not successful; there are also no data on the hybrids between *Ae. ventricosa* with the soft wheat in the wide literature on the hybridization of *Aegilops* with wheat.

On the other hand, *Ae. ventricosa* may be comparatively easily crossed with the group of hard wheats; thus, for instance 54.3 per cent of the crosses between *Ae. ventricosa* with *Tr. dicoccoides* are successful(6). We had numerous hybrids from crosses between *Ae. ventricosa* with *Tr. dicoccum*, *dicoccoides*, *Timopheevi*, *turgidum* and *polonicum* which showed no bivalents whatever in the meiosis of the F_1 or had only occassional bivalents of the so-called open type*. *Ae. ventricosa* shows therefore no homology of its genoms with the genoms *A* and *B* in wheat and probably the homology found refers to the genom *C* of *Tr. vulgare*.

The establishment of the genom homology between *Ae. ventricosa* and *Tr. vulgare* is very important for the understanding of the origin of the above mentioned 42-chromosome form of the *vulgare* type which occurred among the segregants in the F_4 of *Ae. ventricosa*×*Tr. durum* (7,8).

Let us examine in some more detail the problems of homology of the chromosomes of *Aegilops* and wheat; we shall be limited mainly to the data on the conjugation of the chromosomes in meiosis.

Many are greatly interested in the homology of the genoms of the *Aegilops* species with the third genom *C* of *Tr. vulgare* while studying the genom relations in the genera *Triticum* and *Aegilops*. The study of meiosis shows that the chromosomes of *Aegilops* and of the wheat in the majority of cases conjugate end to end, forming no true closed bivalents. Such bivalents are present in a very limited number of combinations in the F_1 *Aegilops-Triticum* hybrids and in considerably higher number of cases in the F_1 between species of *Aegilops* belonging to the common section of the genus. Only *Ae. cylindrica* forms up to 7 condensed bivalents with *Tr. vulgare*, and this exceptional case was described by Sax (4) as early as in 1924, as a verification

* Occurrence of the hybrids *Ae. ventricosa*×*Tr. durum* in nature was noted by many authors, mainly in North Africa; Ducellier (1937) has found them in Algeria in great numbers in a region parallel to the coast (700 km long), especially after rainy summers.

of the Percival's hypothesis (3) on the possibility of co-operation of *Aegilops* in the formation of the 42-chromosome species of wheat and the origin of the third «seven» of *vulgare*.

The karyological investigation of the *Aegilops* species conducted by Senianinova-Korchagina (5) has considerably broadened the ideas on the genom relations in the genus *Aegilops*. The exceptional position of *Ae. cylindrica* among other species of this genus could be explained through the presence in its chromosome set of a genom morphologically identical to that of *bicornis*, a species which is morphologically so closely related to wheat. By crossing the 7-chromosome *Ae. bicornis* with various species of wheat we succeeded in securing hybrids which were completely sterile only with the monococcum group, and in observing in meiosis of the F_1 up to 4 of the so-called open bivalents. The crosses of *bicornis* with *cylindrica* and *ventricosa* could not yet be obtained but in the meiosis of the F_1 hybrid *ventricosa*×*cylindrica* we have discovered 7 true bivalents (6). All these relations may be illustrated by the following diagram (Fig. 2).

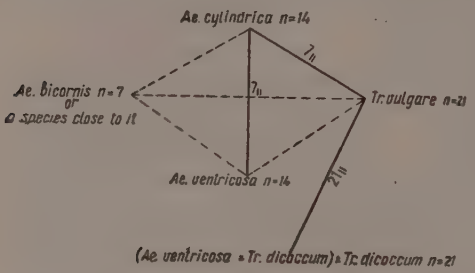

Fig. 2.

The solid line refers to the connections between homologous genoms which are established on the basis of the chromosome conjugation; the dotted line denotes the hypothetical homology which is not yet proved by direct cytological evidence on chromosome conjugation.

We are, of course, far from the idea that *Tr. vulgare* possesses the *C* genom which is identical with that of *Ae. bicornis*; we suggest, however, that the genom of *Ae. bicornis* is homologous to the *C* genom of *Tr. vulgare*, and that this homology may be proved cytologically, possibly through amphidiploids and other polyploid forms. It may be thought also that there was one time in nature a species closely related to *Ae. bicornis* which is now extinguished, and its genom was homologous to the genoms of *Ae. ventricosa* and *Ae. cylindrica*.

In the described case we succeeded in combining the desired species by employing the amphidiploid and the autosyndetic form which was a kind of a side way; the homology of the genoms of *Ae. ventricosa* and soft wheat was thus demonstrated.

The method of combining qualities of species and genera in distant hybridization through amphidiploids and analogous forms appears to be the most efficient one, due to their high crossability with other species and owing to new possibilities in producing combinations which were unsuccessful before.

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GENETICS

INTERSPECIFIC HYBRIDS IN WATER-MELONS

By M. GOLDHAUSEN

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Almost no work has been done as yet on interspecific hybridization in water-melons. The only successful experiments known are crosses between the two most closely related species, *Citrullus edulis* Pang. and *Citrullus colocynthoides* Pang., made with practical purpose by American plant-breeders.

Several years ago the All-Union Institute of Plant Industry accomplished a large series of interspecific crosses in water-melons, the work in question being a part of experimental development of the theory of breeding; from crosses between four species available F_1, F_2, F_3 and F_4 were subsequently grown. The results are summarized in the following 17 points.

1. The following four botanical species of water-melons, out of the six composing the genus *Citrullus*, were experimentally studied: *C. edulis* Pang. (edible water-melon), *C. colocynthoides* Pang. (fodder species), *C. colocynthis* (L.) Schrad. (a wild species inhabiting deserts) and *C. fistulosus* Stocks (a half cultivated endemic species from India). They are not easily crossed and the success of the cross depends upon the choice of the pistil parent (see § 8). The hybrid fruits contain greatly reduced numbers of seeds. The seeds of these fruits are partly malformed and are distinguished by more or less reduced germinating power (table).

Results of Interspecific Crosses in Water-Melons

Species crossed	Percentage of cross-ability	Percentage of hybrid seeds (norm. taken for 100.0)	Germinating power in %
C. edulis×*C. colocynthoides*	31	23—44	57
C. colocynthoides×*C. edulis*	13	44—52	54—95
C. edulis×*C. colocynthis*	3	22—31	62
C. colocynthis×*C. edulis*	22	5—41	35
C. edulis×*C. fistulosus*	0 or very rarely	—	29
C. fistulosus×*C. edulis*	1.5	2.5—11.6	50

2. One may judge to a certain extent of the genetic relationships of the botanical species of water-melons by the crossability and amount of seeds in the hybrid fruits. Most closely related to the edible *C. edulis* is

the fodder species *C. colocynthoides*; then follows the wild *C. colocynthis* and finally the half cultivated endemic species from India, *C. fistulosus*, markedly differing from them. Such arrangement deduced from results of crossing fully agrees with that based upon morphology and geographic distribution of the named species.

3. The difficulties in interspecific crosses in water-melons are probably caused by karyotypic differences and by differences in floral biology and in germination of pollen.

4. The F_1 plants of crosses with *C. edulis* are wholly normal and fertile; only in the hybrids *C. edulis*×*C. fistulosus* a certain reduction of vitality of seedlings and adult plants was observed.

5. Dominance as well as intermediate expression of various characters is observed in F_1; as a rule, characters of the less cultivated and wild forms show dominance.

Phenomena of heterosis in leaf-size, in the length of shoots (crosses *C. edulis*×*C. colocynthoides* and *C. edulis*×*C. colocynthis*), in the number of fruits per plant (in crosses *C. edulis*×*C. colocynthis* and *C. colocynthoides*×*C. fistulosus*) and in the size and weight of the fruit (in *C. edulis*×*C. colocynthoides* and *C. colocynthoides*×*C. fistulosus*) are observed. Hybrids *C. edulis*×*C. fistulosus* show in F_1 a very clear matrokliny in the majority of characters.

6. In F_2 and F_3 of the cross-cycles in question no clear phenomena of monstrosity, lethality or transgression beyond the limits of species and genus were discovered except the following:

a) individuals of the F_2 hybrids *C. edulis*×*C. fistulosus* are distinguished by low vitality;

b) in F_2 from the hybrid *C. edulis*×*C. colocynthoides* entirely new colours of the flesh appear (orange, pumkin-yellow, green).

c) in F_3 of the hybrid *C. edulis* (with entire leaves)×*C. colocynthis* there appeared plants with gigantic leaves.

7. The segregation in the F_2 of the interspecific hybrids is a very complex or polymeric one with respect to all the characters. In the matroklinous hybrids *C. edulis*×*C. fistulosus* only a slight quantitative segregation was noted and, besides, only in certain characters (shape of the fruit, coloration of the flesh, percentage of sugar in the flesh, number and length of shoots).

8. Commercial crossing for breeding purposes of species of water-melons should be made (for Central Asia) in numbers large enough for 18—22 per cent successful crosses for hybridizing *C. colocynthis*×*C. edulis*, 2—5 per cent for the reciprocal cross; 10—13 per cent for hybridization of *C. colocynthoides* with *C. edulis* and 25—30 per cent for the reciprocal cross. It should be kept in mind that the number of seeds is smaller in *C. colocynthis* than in *C. edulis* and *C. colocynthoides*; it is not profitable, therefore, to use, ceteris paribus, this species as the pistil parent.

9. Hybrids between varieties of *C. edulis* and *C. colocynthoides* may be used for isolating in the F_2 forms of the edible type possesssing excellent, surpassing the parent *C. edulis*, solid and more endurable flesh. Such forms are met in small percentage so that the scale of the commercial cultivation of the F_2 should be a considerable one.

10. Forms of the fodder-type possessing more tender and sweet flesh as compared with the existing varieties may be isolated in the F_2 of the crosses noted above in much higher quantity. It was already done by the work of the American breeders.

11. Hybrids of the varieties of *C. edulis* with *C. colocynthoides* prove that bitterness and toxicity of the fruits of the latter species caused by the

presence of the glucoside colocynthine, are characters of dominant polymeric nature; therefore, for the breeding of valuable non-bitter constant recessives the work should be conducted on a large scale, not less than 1000 individuals of F_2 being necessary. In absence of such forms the least bitter fruits should be selected and F_3 grown from their seeds; there should be considerably more non-bitter forms in it.

12. From non-bitter water-melons in subsequent generations forms of edible type segregate out; they possess exceptionally solid or tender flesh (winter water-melons which were unknown as yet), and among them there are forms approaching in habitus and in the characters of leaves the colocynth, i. e. suitable for cultivation in deserts. The latter was proved through experiments on cultivation in the Aral Desert in 1937 where they developed without irrigation under conditions non-suitable for cultivation of ordinary water-melons.

13. Apart from the above said it is possible to isolate from the F_2 of the hybrids *C. edulis*×*C. colocynthoides* exceptionally many-fruited forms of edible and fodder-types with 10—15 and even more fruits per plant instead of the 3—5 (super-yielding water-melons).

14. All the F_2 forms noted above (§ 12, 13) are coarse, deficient in sugar and need to be further hybridized for lowering the percentage of pectinous stuffs and cellulose as well as for increasing the percentage of sugar.

15. In some of the hybrids *C. edulis*×*C. colocynthis* heterosis as expressed in the strong growth of shoots in F_1 is transmitted to F_2, though to a somewhat smaller extent; this phenomenon is recorded as being negative from the breeders' viewpoint.

16. Hybrids *C. edulis*×*C. fistulosus* have no practical value; they are, however, of theoretical interest for they display a clear matrokliny in F_1, F_2 and F_3. This will be discussed elsewhere.

The species *C. fistulosus* is valuable for breeding purposes only when crossed with *C. colocynthoides*; it improves the fodder qualities of the latter species, lowers the percentage of the pectinous materials and increases the number of fruits per plant.

17. The study of chemistry of the interspecific hybrids of water-melons indicates that there are great possibilities before the breeder in this field.

A special communication will be devoted to the chemistry of the interspecific hybrids in water-melons.

Interspecific hybrids of water-melons are of great theoretical and practical interest, and the All-Union Institute of Plant Industry will study them further; new material from South Africa will be included in the studies.

Middle Asia Station
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GENETICS

LIVING ANCESTORS OF CULTIVATED WATER-MELONS

By K. I. PANGALO

(Communicated by N. I. Vavilov, Member of the Academy, 4.VII.1938)

D. Livingstone communicated in 1857 in a book on his exploration of South Africa that in the desert Kalahari there are natural overgrowths of water-melons of various forms, both edible and unedible. This gave foundation for the assertion that South Africa should be considered as the native country of water-melons. Dr. F. Stuhlmann in his well known book (1909) on German East-Africa expressed the opinion that the area where in former times the water-melon now cultivated grew wild, was not limited to South Africa, but penetrated into North Africa, embracing not only Egypt, but even West and South Asia; later on, in more recent times, natural overgrowth of edible water-melons, probably, should have died out, to survive only in Kalahari.

During the 80 years which elapsed since the discovery made by D. Livingstone many botanists have seen and described the wild growing water-melons of Upper Egypt and South Africa; however, nobody has studied them experimentally and in more detail, and it was, therefore, impossible to speak definitely of water-melons as of ancestors of the cultivated varieties. Only in 1937 the All-Union Institute of Plant Industry received with great difficulty from Kalahari, Rhodesia and Upper Egypt 6 samples of seeds of wild growing water-melons; they were raised and studied at the Central Asia Station. The results of these studies are communicated below.

The old botanical species *Citrullus vulgaris* Schrad. enclosed two groups of forms which fundamentally differ from each other and represent, on the opinion of the present writer, two good botanical species; *Citrullus edulis* Pang., including all the edible water-melons, and *Citrullus colocynthoides* Pang., where belong all the forms and varieties of fodder- and candy-water melons. These two species differ from each other more than in twenty morphological characters, they differ chemically and are crossed only with considerable difficulty*. *C. colocynthoides* is a species most closely related to *C. edulis*; farther from it is the wild colocynthis, *C. colocynthis* (U.) Schrader. All the species enumerated above have common chromosome number $2n=22$, and their karyograms are very close to each other. Apart from these three species stands the fourth *C. fistulosus* Stocks, which is entirely different in morphology, possessing a chromosome set both quantitatively and quali-

* The American investigator Baily considered the species *C. colocynthoides* as a mere variety of the species *C. vulgaris* and designated it as *C. vulgaris* var. *citroid*; however, such a taxonomical treatment of fodder- and candy-water-melons is undoubtedly erroneous.

tatively different from those of the described 3 species, 2 *n* being equal to 24; this species is endemic in India and has not been found in Africa.

Besides the enumerated above species of water-melons which have been studied experimentally under cultivation, two more South African species of water-melons are known from literature, namely *C. Naudianus* (Sond.) Hook. f. and *C. ecirrhosus* Cogn.; they have not been introduced as yet into the experimental field. On the opinion of the present writer there are all grounds to unite the species *C. edulis*, *C. colocynthoides* and *C. colocynthis* into a common group *Citrullus* consp. *africanus* Pang. in contrast to the India species *C. fistulosus*.

Forms of the wild-growing water-melons from Kalahari and S. Rhodesia which were studied at the All-Union Institute of Plant Industry past summer all belong without doubt to *C.* consp. *africanus*. While studying them in the beds one gets a general impression that all the three species mentioned above are present there; however, the limits of the species are not clearly distinct owing to overlapping of specific characters in these forms.

The majority of Kalahari and Rhodesian water-melons belong to the species *C. colocynthoides* judging by the habitus and by a series of single characters; some of them possess, however, leaves of typical colocynths, others—of typical edible water-melons; the odour of leaves in all of them is highly disagreeable, of the kind peculiar only to colocynths; the flowers are of the type of colocynth, of edible water-melons and of intermediate type; even the flesh which undoubtedly belongs to *C. colocynthoides* is atypical and somewhat resembles that of *C. edulis*; the seeds in certain characters are intermediate betwen these two species, while in shape they are entirely singular and closely resemble those of melons. Peculiarity may be seen also in the patterns of the peel of fruit in certain forms; they are of a light whitish-green colour, covered with dark-green splash-like spots, distributed quite disorderly, which was as yet not found in water-melons; all the forms of water-melons known develop patterns which are arranged radially.

Two forms of colocynth from Upper Egypt displayed a situation identical to that in the forms of the fodder-water-melon just described: they had leaves very similar to those of the edible water-melon; the specific odour of the leaves of colocynth was weakened; the pattern of fruits approached the ordinary pattern in edible water-melons, i. e. represented scalloped solid bands; the flesh was more juicy than in ordinary colocynth, and (which is more important) it was not bitter but even somewhat sweet; finally, the seeds were fully uncommon for the colocynth being white with a fringe—genuine seeds of *C. edulis*.

Out of the forms described here to the species *C. edulis* belongs only one from Upper Egypt. It was distingushed by leaves somewhat resembling those of colocynth, by small and narrow bracts and flowers of the type of colocynth; flesh undoubtedly belonged to *C. edulis* but possessed pale, somewhat muddy coloration and was not very sweet; seeds were of the edible type.

All the forms of Kalahari, Rhodesian and Upper-Egyptian wild water-melons are very late and very viable; they began to bloom at the time when the cultivated varieties of water-melons had already developed very noticeable young fruits, and in the autumn, when the water-melon field naturally dies, the wild African forms were distinguished through their vivid green and bloomed abundantly. All of them had fruits of a somewhat rough shape, a little angulate, far from the equal «turned» fruits of the cultivated water-melons. The fruit pattern of the forms in question also was a rough, primitive, indistinct, poorly organized, in comparison to cultivated varieties. The flesh proved to be equally coarse. The pistil-flowers in all of them were hermaphroditic.

In summing up the results of preliminary studies of the South African wild water-melons one should say that the student faces here forms entirely new to botanists. It is premature as yet to taxonomize them; however, one may speak with sufficient probability of their representing new subspecies and varieties. They are not well differentiated and possess characters of neighbouring species as well as characters which are not yet formed or are of primitive kind; they are rough and do not show the «grinding» and specializing action either of natural or artificial selection. Anyhow, it would be hardly a mistake to consider the forms under discussion as the nearest ancestors of the three botanical species which compose *C.* consp. *africanus**. They are undoubtedly relicts of those remote times when the contemporary species *C. colocynthis*, *C. colocynthoides* and *C. edulis* did not yet exist, when this specific differentiation was far from being completed, and the divergence of forms was slight, the forms have not yet lost mutually related characters and preserved characters of their remote common ancestor.

In the thickets of S. Africa and Egypt grow number of highly interesting water-melons which are rather often but fluently mentioned by botanists and explorers; nobody has studied them seriously. Besides the known forms a series of unknown relicts of remote times surely survived there in deserts as if in natural vivaria; they may serve to trace with great exactitude the evolution of contemporary cultivated water-melons. The All-Union Institute of Plant Industry takes all measures to secure from the depths of Africa as many forms as possible in order to subject them to a careful experimental study. At present the cucurbitologists at the Institute dispose of a series of new seed-samples from Kalahari, Rhodesia and other localities of South Africa; the characters of their seeds alone prove that they are very interesting novelties which had never before been handled by investigators.

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* The hypothesis that the new forms of water-melons described here are natural interspecific hybrids should be rejected since the latter have been produced and studied in several generations by M. K. Goldhausen of the All-Union Institute of Plant Industry and showed no resemblance to wild forms of Kalahari, Rhodesia or Upper Egypt whatever.

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PLANT PHYSIOLOGY

STAGE-DEVELOPMENT IN DIFFERENT BIOLOGICAL GROUPS OF LETTUCE (*LACTUCA SATIVA* VAR. *CAPITATA*)

By F. E. REIMERS

(Communicated by A. A. Richter, Member of the Academy, 1.VII.1938)

In a series of previous investigations it was established that both shooting and flowering in lettuce can be accelerated by keeping the germinating seeds at low temperature and cultivating the plant under the conditions of prolonged day. Shortening of the duration of the day, on the contrary, retards the process of development in this plant ([1],[2],[3],[4]).

Very interesting attempts were also made to apply shortening and prolongation of the day to the study of genetic differences between winter, spring and summer forms of lettuce ([5],[6]).

In contrast to the investigations mentioned above we attempted in our experiments to solve the question as to the causes of differences in the time of shooting in different varieties of lettuce from the viewpoint of the theory of stages of development of plants advanced by T. Lyssenko([7],[8]).

We studied therefore in lettuce the conditions and periods of the two known stages of development (yarovization stage and light stage).

From the great many varieties of head-lettuce (*Lactuca sativa* v. *capitata*) were selected several varieties which sharply differ in earliness and are typical representatives of various biological groups of this subspecies.

The following varieties were taken for the yarovization experiments; Ideal, Eier Gelber, Steinkopf, Trotzkopf. The light stage of development was studied in the same varieties but, instead of the variety Steinkopf, was included the variety Gr. Blonde Paresseuse which was obtained somewhat later.

Ideal is a typical spring variety, Gr. Blonde Paresseuse—a typical summer variety. The remainder assume intermediate positions between these extreme forms.

The purpose of the experiments reported below was to:

1. Determine the duration of the yarovization and light stages in the representatives of different groups of lettuce.

2. To clear up the possibility of splitting varieties of lettuce into biological strains by application of methods of stage analysis as worked out by T. D. Lyssenko ([9],[10]).

3. To ascertain the response to yarovization of varieties differing in the length of the growth period when (a) germinated seeds and (b) green plant are subjected to yarovization.

The last problem was raised in connection with the fact that in some vegetables (cabbage, turnips) yarovization gives better results when applied to green plants instead of germinated seeds([11],[12],[13]).

The method of yarovization was the following. Seeds of lettuce were germinated until about 5 per cent of them showed the first appearance of rootlets. The seeds were thereupon transferred to a room with a temperature kept within +2.5—5° C. The yarovization periods lasted 10,20 and 30 days respectively.

Seeds which were germinated under normal conditions of heat until they reached the same stage as the yarovized ones were planted to serve as a con-

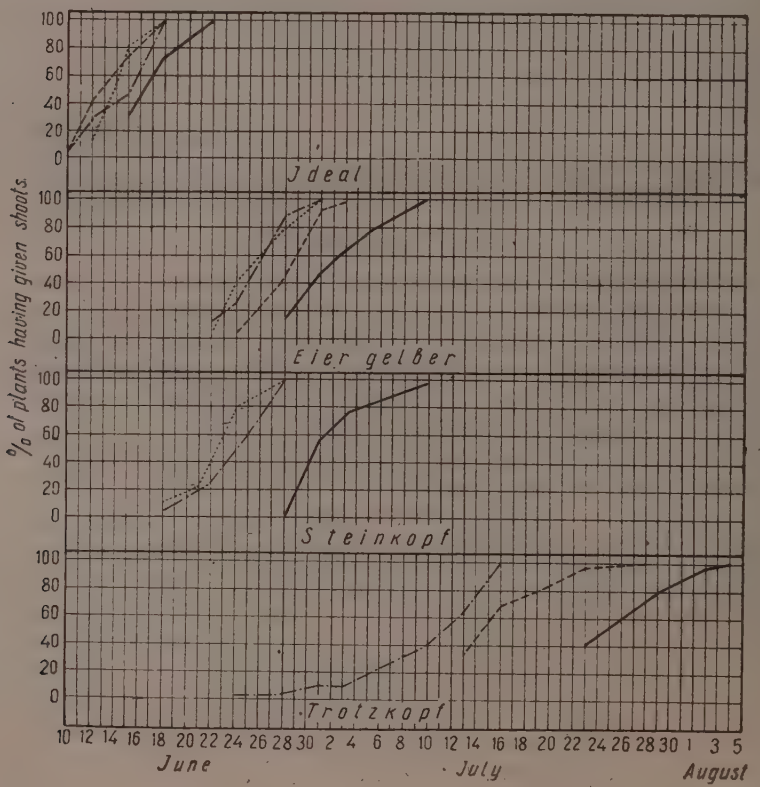

Fig. 1. Process of shooting as influenced by seed yarovization.

Symbols
. . . . . yarovized for 30 days
— . — . » » 20 »
— — — — » » 10 »
——— Control

trol. The yarovized and control seeds were planted in beds simultaneously, on the 5 of May.

Each experiment was conducted in two parallel lots containing 40 plants each. Further observations on individual plants were made.

Both yarovized and non-yarovized seeds gave young growth on the 11—12 of May.

Different variants of the experiment did not differ within each variety in the rate of approach of the first phases of development either (formation of the 1, 3, 5 leaves).

The total number of leaves set by a plant until the formation of the flower shoot was equal in all variants.

Shooting began on the 10 of June.

Yarovization accelerated shooting in plants of the variety Ideal for 3—5 days (Fig. 1).

No striking differences in the time of arrival of shooting as influenced by various dosages of yarovization were detected in this variety, and the observed difference in the dynamics of the shooting of plants produced from the seeds yarovized during 10, 20 and 30 days falls within the limits of experimental error. On the other hand, the difference in time and course of the shooting in yarovized and non-yarovized plants is significant. The yarovization stage is thus passed by this variety in 10 days. The same period of yarovization is insufficient to complete the yarovization stage in other later varieties, Eier Gelber, Steinkopf and Trotzkopf. This could be concluded from the fact that longer periods of yarovization (20 and 30 day) caused earlier shooting than that taking place after 10 days yarovization.

Thus, while yarovization of germinated seeds during 10 days is sufficient for the completion of the yarovization stage in the early variety Ideal, in later varieties the yarovization stage is longer and takes about 20 day.

The results of this experiment show that different varieties of lettuce, like those of wheat, differ in the length of the yarovization stage; this determines to a considerable extent under the conditions of practical spring sowing their earlier or later shooting.

The experiment on yarovization of green plants of lettuce was conducted in the following way. Seeds of the same varieties that were used for the experiment on yarovization of seeds, were planted into plots. At the phase of formation of the 1st leaf the plants were transferred to a room with the temperature from +2.5° to +5°C where they remained under the illumination of 100 W electric bulbs which hung over the plants at a distance of 0.5 m, one lamp per 1 m^2. The length of yarovization was fixed 10 days.

During yarovization the plants have already shown symptoms of being affected by the low temperature. Loss of turgor by leaves was observed, growth has completely ceased, leaves became yellow.

The control plants sown in plots at the same time and kept under natural illumination and temperature (from +18 to +20°C) continued growth and had normal appearance.

After the term of yarovization was completed both yarovized plants and those grown at high temperature were simultaneously transplanted to open ground; seeds of the same varieties of lettuce were planted also in the nearest vicinity.

Yarovization of green plants as applied by us has consideradly slowed down the growth of the lettuce plants as well as their shooting. The shooting of yarovized plants took place not only later than of those grown from seeds planted at the same time with those from which the plants subjected to yarovization were raised, but even as compared with plants which developed from seeds planted at the time when the yarovized and control plants were transplanted.

It thus became clear that, although the optimal temperature for completion of the yarovization stage by seeds of lettuce is from +2 to +5°C, the same temperature produces a deleterious effect upon the green plants of this crop, inhibiting their growth and development.

In this connection it is of interest to compare the following data. As noted above, cabbage and turnips do not become yarovized at the stage of germinated seeds, radish may be yarovized, according to the data of L. M. Dorokhov both as green plants and as germinated seeds, while lettuce can be yarovized only at the stage of germinating seeds.

The experiments on the conditions the light stage proceeds under and the duration of the development in lettuce consisted in the following. Seeds of the varieties Ideal, Eier Gelber, Trotzkopf and Gr. Blonde Paresseuse were simultaneously sown in open plots; the soil was carefully mixed to the depth of 35—40 cm.

After the appearance of young growth and till the end of vegetation plants of different plots were exposed to daylight for a) 10 hours, b) 14 hours, c) from

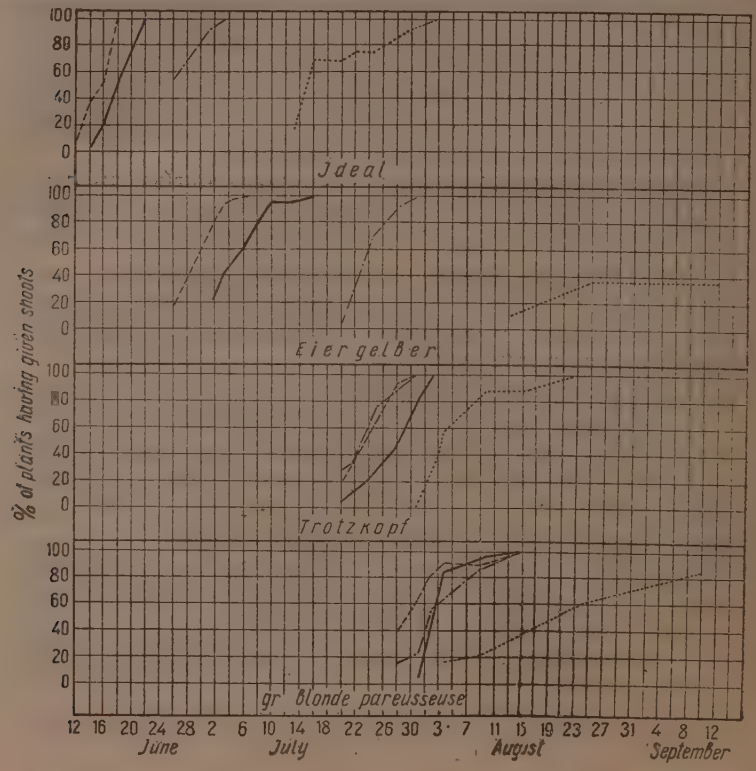

Fig. 2. Process of shooting in lettuces grown at different day length.
Symbols: ——— natural day length
— . — . 14-hour day length
— — — 24 » » »
. . . 10 » » »

sunrise to sunset, d) received during the whole night additional electric illumination (last plot).

Young growth appeared simultaneously on all the plots. The course of development of plants of different plots later on proved, however, strikingly different (Fig. 2).

We have noted that yarovization caused a great reduction of the growth period in late varieties (Trotzkopf) while it exerted a considerably slighter influence upon the early varieties (Ideal, Eier Gelber). The dynamics of the shooting represented in Fig. 2 points to an entirely opposite effect of the length of the day upon these varieties. In the case in question the shortening of the day greatly retarded shooting just in the early (winter) varieties; the effect was quite insignificant in the late (summer) varieties.

Curves of bloomig have an analogous aspect in the two cases.

Comparison of the experimental data on yarovization (Fig. 1) with those on cultivation of lettuce at a different day length (Fig. 2) makes it possible to draw the following conclusions.

Biological difference between the winter and summer varieties of lettuce consists in the fact that while the former have a short yarovization stage and a long light stage, the latter, on the contrary, possess a long yarovization stage and a short light stage.

Cultivation of lettuce-plants at a different day length exerted a material influence upon the external characters and the behaviour of different plants within the same variety.

At a natural day length, as well as at a 24-hour day, plants of each variety were uniform in all respects. Even the height of the plant varied only within

Fig. 3. Plants of different varieties of lettuce grown in 24-hour day. № 1—Ideal, № 2—Eier Gelber, № 3—Trotzkopf, № 4—Gr. Blonde Paresseuse, Photo 11. VII.

the limits of 3—5 cm. The judgment of eye could detect no difference between the plants belonging to one variety.

An entirely different situation was observed in plants grown under the conditions of 14 and, especially, of 10-hour day. Plants belongig to one and the same variety differed here strikingly in the general shape and in a series of other morphological characters, as well as in time of shooting.

The accompanying Fig. 3 and 4 prove it.

Attention is drawn to the difference in the morphological character of three plants of the variety Ideal represented on the Fig. 3 (the row labeled № 1). The plant distinguished by the label № 9 has a typical «alpine» shape. A broad rosette of leaves is pressed to the soil. The plant at the extreme right (bearing label № 10) has formed a rather condensed head.

The results of our experiments enable as to confirm the conclusion previously made by T. D. Lyssenko also for different varieties of lettuce, namely, that a variety well selected under the conditions of the normal length of day is nevertheless a population (mixture) composed of biological races differing with regard to their physiological properties.

These differences among which there are such of commercial value are manifested only when the variety is grown under changed conditions. Owing

Fig. 4. The same plants at the same time but grown in the 10-hour day.

to the fact that the length of the day exerts the strongest influence upon the development of lettuce, differences between the plysiological races are strikingly manifested when this factor is changed.

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PLANT PHYSIOLOGY

ON THE CHANGE OF THE «SIGN OF THE PHOTOPERIODIC REACTION» IN TURNIPS

By F. E. REIMERS

(Communicated by A. A. Richter, Member of the Academy, 1.VII.1938)

Turnips (*Brassica rapa* L. subvar. *petrovskiana*) variety Petrovskaia served as material for the experiment the results of which are communicated below.

Turnips are classified into the group of «the long day plants» ([2],[3]). In the monograph on *Cruciferae* E. N. Sinskaia writes: «Turnip belongs to „long day" plants: shortening of the day by shading postpones the moment of flowering and stimulates thickening of the root» (p. 127). Analogous data are found in the work by Lundegardth ([1]).

We approached the study of the light stage of the development of the turnip by forcing this plant to pass through the whole life cycle, from seed to seed, during one year by means of yarovization.

The works conducted by Sukorzeva ([4]), Edelstein and Sukorzeva ([6]), Chesnokov ([5]) and our experiments made at the Institute of Vegetable Industry have demonstrated that yarovization of the sprouting seeds of turnips never causes 100 per cent turnip-plants to bloom.

On the other hand, when seedlings of turnips grown in the soil are yarovized during 30—35 days, from 98 to 100 per cent of the resulting plants develop stalks. Plants which develop stalks the first year give under ordinary conditions of cultivation normal yield of seed.

We therefore applied in the present experiment the last mentioned method of yarovization.

On the 3rd of March, 1937, seeds of turnips were sown in a pot filled with rich garden soil. During 5 days the pot was in a hot-house. On March 8 when young growth appeared but the cotyledons of the seedlings did not yet spread the pot was moved to a completely dark room where a temperature from +1 to +3° C was kept.

After 30 days (on April 7) the pot was taken from the yarovization chamber to a non-heated green-house. On the 22th of April the plants were planted in beds. Subsequently all the plants planted in beds gave flowering shoots (on the 27th of May), and all of them bloomed (on the 17th of June).

On the 9th of May, when all the plants developed 3 true leaves, part of them were again transferred from beds to pots 12 cm in diameter, in order to conduct a preliminary experiment on the influence of the light regime on the jarovized plants.

One group of plants (12 pots) was placed under the conditions of 8-hour day, and an identical group was raised under a 24-hour illumination. The

The Course of the Development of the Turnip-Plant in the 8-hour Day

Plant №	The moments of setting in of phases of development				Notes
	Stalk formation	Flowering	Formation of pods	Maturation	
1	7.VI	16.VI	20.VI	9.VII	Normal fructification
2	5.VI	12.VI	16.VI	7.VII	» »
3	—	—	—	—	The plant has developed no flower-bearing shoots
4	7.VI	15.VI	20.VI	10.VII	Normal fructification
5	10.VI	17.VI	—	—	Flowers are morphologically defective (no anthesis or only one petal opened up). Flower buds dried up and dropped. There were no pods
6	10.VI	17.VI	—	—	Same as plant № 5
7	20.VI	17.VI	—	—	The plant has produced a flowering shoot. Rudiment of flower buds dropped down. There were no flowers. The plant died on 17. VI. No injury by any pest could be detected
8	22.VI	—	—	—	Same as plant № 7
9	5.VI	12.VI	16.VI	7.VII	Normal fructification
10	5.VI	12.VI	16.VI	7.VII	» »
11	—	—	—	—	Plant destroyed by pest
12	—	—	—	—	» » » »

temperature (8-hour day and 24-hour day) was identical in both rooms (variation within the limits of 1—2°).

Up to the second transplanting all the plants were subjected to the influence of the natural day, the duration of which at the latitude of Moscow at that period varied from 13 h. 32 m. to 15 h. 52 m. (from the sunrise to the sunset).

Observation on the transplanted plants were conducted till September 9. The results of the observations are presented in the table.

As may be seen from the table, out of ten plants grown in the 8-hour day, 9 gave flower-shoots, 7 developed flowers and 5 produced fruits in a normal way.

Attention is drawn to the fact that the 8-hour day did not prevent at all the formation of flower-shoots; it did influence, however, in some plants the further formation of the flower-buds and flowers.

All the plants grown at the 24-hour day were at the rosette stage during the whole period of the experiment (till September 9). None of them gave flower-shoots.

At the 8-hour day none of the plants produced roots. At the 24-hour day the plants developed roots of the size of a walnut.

It is necessary to note that pots which contained plants were too small for such plants as turnips. This evidently was the cause of the fact that roots of plants grown in the 24-hour day were small.

We understand that the data of our experiment of 1937 do not permit of a categorical assertion that the ligth stage of turnips is passed in the short day. The inadequacy of the experiment consisted in the fact that the plants were grown under the conditions of the natural day after yarovization and prior to being placed under experimental condition and could, consequently, pass the light stage of development.

The results obtained in 1937 make us, however, advance two probable assumptions bearing on the problem under discussion.

First, it may be assumed that in the case of acceleration of the rate of development of the turnip-plant as compared with the normal one by means of yarovization of the seedlings and of «transformation» of the biennial into annual, the sign of the photoperiodic reaction of the turnip-plant is changed into the opposite.

When we give up the assumption that turnip becomes after yarovization a «short-day plant» we are forced to assume, on the basis of the data contained in the table, that the 24-hour day after the passage of the light stage in yarovized turnip-plants does not suit the complement of the external conditions which are necessary for the passage through some further stage of the development of this plant. The latter appears to be an indirect indication of the existence of this stage in the development of the turnip-plant.

Our experimental data are opposed to those widely spread in the literature and, one may think, supported by the practical observations, namely, that one of the biennials belongs to the category of the «long-day plants»; they anyhow make us raise the question on the revision of the method of study of the individual development of biennials.

The experience of the preliminary yarovization in the study of the light stage of the development of the turnip-plant shows that further application of this method is promising for the elucidation of the character of the process of development of biennials.

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PLANT ANATOMY

ON THE ENDOSPERM NUCLEUS AND ITS RÔLE IN THE FILLING AND RIPENING OF THE GRAINS OF CEREALS

By V. G. ALEXANDROV and O. G. ALEXANDROVA

(Communicated by A. A. Sapehin, Member of the Academy, 29.VI.1938)

It was shown as early as in 1896 that the nuclei of the endosperm cells in mature grains of cereals are greatly deformed (1). Deformation of the nuclei which evidently takes place in consequence of pressure exerted by starch grains filling up the cells is a result of dying off of these nuclei (2). Not uncommonly the nuclei of the endosperm cells at full or the so-called dead maturity of the grain are not only converted into amorphous lumps but are almost dissolved (3). The process of dying off begins by the disappearance of nucleoli which is followed by the break down of the chromatin reticulum. Nuclear desorganization is manifested rather early and spreads from the central parts of the endosperm toward its periphery. Along with a very early beginning of the dying off of nuclei intense vacuolization of the protoplasm around the nuclei is observed. The formation of vacuolae begins very early, long before cell-walls in the endosperm are formed and when the nuclei are engaged in intense division, i. e. when the endosperm tissue may be considered as being entirely meristematic. Both the precocious vacuolization of the protoplasm and the strongly expressed dying off of the nuclei represent most peculiar phenomena which are inherent to the endosperm of cereals when it is being formed and clearly distinguish the behaviour of the living contents of the cells of this tissue from the contents of cells of tissues of other parts of the plant.

In the present paper we shall deal only with some details of the condition of the nucleus in endosperm cells which, to our opinion, are connected with the peculiarities of the ripening of the grain.

In one of our communications (4) was given an account of the results of investigations on the structure of the grains of *Agropyrum*. The investigation revealed very peculiar features in the structure of the endosperm in *Agr. cristatum*: in each cell of the central part of the endosperm is present a small but well formed drusa of calcium oxalate while chondriosomic starch is entirely absent. Special observations have shown that the drusa of calcium oxalate is formed instead of the cell nucleus which degenerates and is decomposed. In species of *Agropyrum* in the endosperm of which drusae of calcium oxalate fail to form, the nucleus is also often decomposed almost without rest; chondriosomic starch, however, is deposited in abundance. These observations made it possible to advance the following two important assumptions: 1) the formation of chondriosomic starch is undoubtedly correlated with

the activity and condition of the nucleus of the cells of the endosperm; 2) formation of the chondriosomal starch is evidently a direct result of the normal process of degeneration and decay of the nucleus. Our further investigations furnished facts which, to our opinion, prove these assumptions.

Chondriosomal starch is the most important factor of the filling of the grain. It fills up spaces between starch grains produced by the plastids and being stored in one or other quantity causes various degrees of filling. In absence of the chondriosomal starch the grains of wheat become meagre ([5],[6]). Under various climatic conditions and depending on the ecological type of the wheat filling proceeds with different velocity and attains at the moment of full maturity different completeness. Particularly slow is the rate of the filling and ripening beyond the Polar Circle. In order to follow up certain details of the process of filling of the grain of wheat which cannot be grasped under ordinary climatic conditions we have collected and fixed (alcohol with a small amout of acetic acid) grains of various wheats at the fields of the Polar Branch of the All-Union Institute of Plant Industry (Khibiny). Material was collected on the 4. IX. 1936. At this late date, immediately before the harvest, grains of the majority of wheats were at milk-ripeness and only some of them attained the condition of early waxy-ripeness. Wheat matures at Khibiny after being harvested, i. e. in sheafs.

Fig. 1.

The accompanying figures represent cells of the central part of the endosperm. Sections of wheat from Finland and Iran were imbedded in glycerine and investigated nearly after a year and consequently were well cleared. Sections of the Polish wheat were cleared with chloral hydrate shortly before investigation and were similarly imbedded in glycerine.

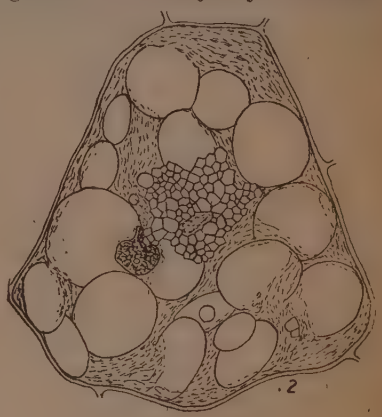

Fig. 2.

Fig. 1 represents two cells of the endosperm from the middle part of the grain of *Tr. vulgare* var. *erythrospermum* Körn. from Finland (K. 19315). In the cell cituated to the left the nucleus is just slightly deformed, possesses a nucleolus and has the general appearance of a normal nucleus of an endosperm cell. There is no chondriosomal starch excluding eight small kernels located at the periphery of the cell at some distance from the nucleus. In the cell to the right the nucleus is strongly deformed, has no nucleolus, but the remnants of the nucleus are surrounded by a closely adjoining mass of chondriosomal starch. The sections were thick and each contained not less than 3—4 rows of cells; there could therefore be no suspicion that nuclei

were cut through and deformed in the preparation of the section. The deformation of the nuclei was, moreover, often observed in all cells of the section.

Fig. 2 represents a cell of the endosperm from the middle of the grain of *Tr. vulgare* var. *ferrugineum* Al. from Iran (K. 14335). The nucleus is deformed and greatly reduced in relation to the cell size (compare with the nuclei of Fig. 1 which were drawn under the same magnification). Near the nucleus is situated a large group of chondriosomal starch.

One more example should be quoted. Fig. 3 represents two cells of the endosperm from the top of the grain of Polish wheat, *Tr. polonicum* L. (K. 7045). The slide was cleared in chloral hydrate, the cell-walls may be distinguished with great difficulty, only silhouettes are left of the starch grains. In the

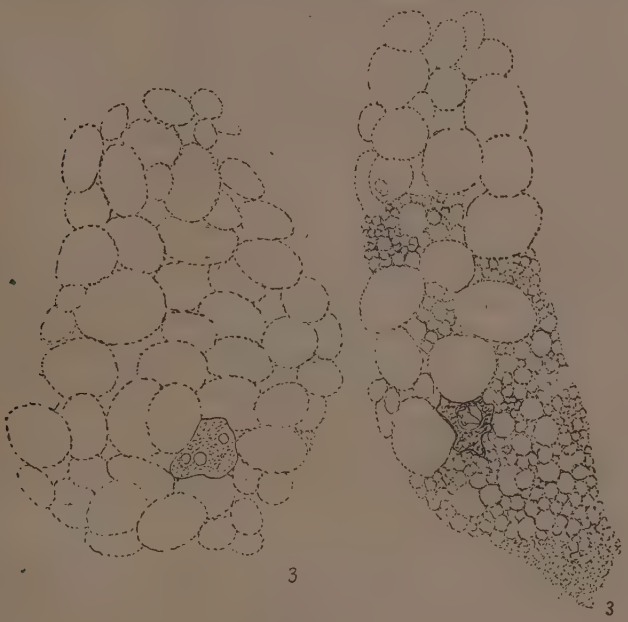

Fig. 3.

cell located on the left side the nucleus is insignificantly deformed and has three nucleoli; in the right-hand cell the nucleus is strongly deformed, and has only one nucleolus containing an inclusion. It may be well seen that the immediately adjoining starch grains take part in the deformation of the nucleus. There is no chondriosomal starch in the left cell, the right cell is rich in this starch, and its deposition takes place on the side where the nucleus is situated.

The above examples convince one that the nucleus of the endosperm cells has direct relation to the formation of chondriosomal starch. The way this connexion is brought about lacks clearness for the present. It may be only asserted that the formation of chondriosomal starch is connected with the processes of degeneration and destruction of the nucleus and, moreover, with the normal course of these processes. It may be also assumed that the deformation of the nuclei of endosperm cells caused by the pressure of the surrounding starch grains is a postmortal phenomenon, i. e. the nucleus dies first and only later its deformation takes place. Therefore, not the defor-

mation appears to be the cause of the death of the nucleus, as is assumed by some investigators, but it seems to be the consequence of death. Cells with dying nuclei continue to live for some time, i. e. their cytoplasm and plastids to a certain extent keep the activity of life, but the co-ordination of the activities of these elements of the cellular contents is disturbed. Just in consequence of this the grains of cereals become overcharged with starch, the filling of the grain takes place. The conclusion is this: dying off of the nuclei in the endosperm cells promotes filling of the grain. In fully ripe grains the endosperm represents a physiologically dead tissue. Several investigators point to this ([7],[8]). The embryo could hardly get from the living endosperm tissue materials which are necessary for germination and further development. Consequently, the process of full maturity of the grain itself is most intimately correlated with the death of the nuclei of the endosperm cells; evidently the different duration of the so-called after-harvest ripening to a certain extent reflects the differences in the velocity and completeness of the destruction of the nuclear apparatus.

The dying off and the deformation of the nuclei takes place not only in the cells of the maturing endosperm in cereals. The same phenomena occur in various plants in endosperm cells or in cotyledons of the seeds ([9]). In all tissues where reserve stuffs are stored the nuclei are often deformed, especially when these tissues are aged.

The figures presented here demonstrate the initial stage of the formation of chondriosomal starch which effects the filling of the grain. In the endosperm of the soft wheats this starch fills up at the end of ripening all the spaces between the grains of the plastid starch, leaving thus very little room for the protein layers. It is not clear as yet what is the course of the filling, what are the impulses that influence it. It should be only noted that Lampe observed in the young endosperm of Indian corn energetic streams of cytoplasm ([10]).

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PLANT ANATOMY

ANATOMICAL PREMISES FOR BREEDING LARGE-ROOTED FORMS OF KOK-SAGHYZ

By V. J. RUDENSKAJA

(Communicated by N. I. Vavilov, Member of the Academy, 4.VII.1938)

In introducing kok-saghyz into cultivation there arose a question on making its root larger so as to approach in type that of root-crops.

At present, under common conditions of cultivation, the mean diameter of the root of kok-saghyz (at the root-neck) is from 0.6 to 0.7 cm. When the plants are set more apart, the diameter of the root may attain 1.5—2.0 cm (at the root-neck); in single outstanding plants it may even reach 3.0—3.5 cm.

Breeding large-rooted varieties of kok-saghyz is the principal task of the breeder working with this plant.

As the contemporary mass selection is based on the character of the root-size, it appeared to us necessary to analyse the structural alterations which determine the rubber content of the roots as connected with their enlargement by breeding methods.

Kok-saghyz belongs to plants whose root serves for storing reserve materials.

It is known from old works ([1],[2],[3]) that the storing tissue may be of very different origin. In some plants it is the primary cortex, in others—the secondary cortex and in third—the wood-parenchyma.

Dandelions, including kok-saghyz, belong to the type where the greatly developed bast parenchyma of the secondary cortex serves as storing tissue.

Cells of cortex are formed in kok-saghyz by cambium much more actively than those of xylem; the area of cortex, as seen on cross-sections, therefore always exceeds many times that of xylem.

Enlargement of the root in kok-saghyz thus occurs on the whole at the expense of increase of the volume of cortex.

This is a very satisfactory situation since the system of latex-vessels which is of prime interest is situated just in the secondary cortex. The wood, on the other hand, is useless from the practical point of view.

We have shown in a previous paper([4]) that along with the growth of the root in width, latex-vessels are dispersed within the tissue, i. e. their number per unit of area of the cross-section of the root is decreased. As the large-rooted forms of kok-saghyz essentially differ from small-rooted ones in more rapid growth of roots in width, the question naturally arose as to the possibility of stronger dispersion of latex-vessels and, consequently, of decrease of rubber content in large-rooted forms as compared with those exhibiting slower growth.

After having investigated the material taken from a population at the end of the growth period we have found that a strong dispersion of latex-vessels in large roots really takes place. Thus, roots of three size groups (I, II, III), which were collected in September from 97 plants, gave the following results:

Table 1

Group	Number of roots per group	Area of the cross-section in mm²	Number of latex-vessels per 1 mm²	Total number of latex-vessels per cross-section
I	29	42.5	75	3212
II	32	33.3	80	2671
III	36	26.4	97	2561

The total number of latex-vessels per section increases with the enlargement of the root, while their number per unit of area diminishes; the absolute quantity of rubber per root is evidently increased. However, the increase of the total amount of rubber is not proportional to the size of the root owing to the dispersion of latex-vessels in larger roots. As a consequence large roots are characterized through lower percentage of rubber.

Table 2

Group	Number of roots per group	Area of section in mm²	Per cent of rubber (micro)
I	29	42.5	2.41
II	32	33.3	2.91
III	36	26.4	3.33

Mass selection for root size may thus lead to a decrease of rubber content unless special control for percentage of rubber is applied.

However, one circumstance may be now indicated which considerably lessens the unfavourable tendency pointed to above. It is the decisive rôle played by the diameter of the latex-vessels.

Table 3

Area of latex-vessels in mm² / Percentage of rubber	78—200	201—300	301—400	401—500	501—
0.92—1.5	3	2	—	—	—
1.51—2.0	1	5	6	—	—
2.1 —2.5	—	9	6	2	—
2.51—3.0	—	4	15	6	—
3.1 —3.5	—	3	7	3	1
3.51—4.0	—	—	4	2	2
4.1 —4.5	—	—	3	2	1
4.51—5.0	—	—	2	4	—
5.1 —5.64	—	—	—	1	1

It appeared that the percentage of rubber is directly correlated with the mean cross-section of the latex-vessels area. The coefficient of correlation between these characters is +0.63 the error being +0.06. The correlation Table 3 containing data of analysis of 96 roots supports the above said.

The size of the latex-vessel thus plays a decisive rôle in determination of rubber content; this was shown also by authors working with kok-saghyz, teke-saghyz and tau-saghyz ([5], [6]). Our work has demonstrated at the same time that there is no definite relation between the area of individual latex-vessels and the cross-area of the root (size of the root) as seen from the correlation table based upon three characters: size of roots, percentage of rubber contained in them and size of the latex-vessels. The sign plus (+) stands for small latex-vessels, those of mean size are designated by squares (■), and large ones by circlets (●) (Table 4).

Table 4

Area of cross-section of the root in mm² / Percentage of rubber (micro)	66—45.0	44.9—41.0	40.9—36.1	36.0—33.1	33.0—30.1	30.0—28.1	28.0—26.1	26.0—18.8
0.92—1.5	+	+ + +	+					
1.51—2.0		■ ■ ■	+ + ■	■ +	■ ■	■		+ ■
2.1 —2.5	●	■ + ■ ●	■	■ ■	■ ■	■ ■		+ ■
2.51 —3.0	■ ■	■	■ ●	■ ■ ■ ● ●	■ ■	■	●	■ ■
3.1—3.5	■	■ ■ ●	●	■ ● ■		■ ■	■ ■	■ ● ■
3.51—4.0			●		● ■	■	■ ■	●
4.1—4.5			■		●	●	■ ●	■
4.51—5.0		●			●	■ ■	■ ●	●
5.1—5.6					●	●		

As may be seen from the Table 4, the size of the latex-vessels is not correlated with the size of the roots. On the other hand, the roots which are the richest in rubber possess, as a rule, largest latex-vessels*.

We thus arrive at a conclusion that the area of a latex-vessel is not a function of the thickness of the root but belongs to genetic characters of the plant.

Special attention should be paid to cases when largest roots with high rubber content do not confirm to the general correlation. Such roots possess large latex-vessels.

Our rather scanty data illustrate only isolated instances. However, these very cases which point to the presence in existing populations of individuals with such a happy combination of characters, assist breeding work, i. e. they are especially valuable for selection. On the other hand, one should note the occurrence, among the largest roots, of those possessing small latex-vessels.

As to the rubber content they fall into the class of the lowest percentage of rubber.

It may be suggested that a specific form distinguished by large roots and very low rubber content is present in the population of kok-saghyz.

This form should be of course eliminated.

The above-said calls attention to the danger hidden in selection for one single character, i. e. for the size of the root. Large-rooted but poorer in rubber varieties may be thus produced.

Selection should be always supplemented with the study of structural characteristics of the plants.

One of the fundamental characters in breeding varieties for the highest rubber content is the large size of latex-vessels. The fact that this character is of genetic nature makes breeding in this direction easier. The production of varieties with large latex-vessels is profitable owing to the comparative ease of latex extraction ([7]) by means of washing, since the flow of liquids from the capillaries is proportional to the fourth power of the radius of the latter.

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* It should be noted, however, that the smallest roots (26.0—18.1 mm²) which are evidently underdeveloped, do not confirm to this rule and possess less rubber, probably owing to incomplete development.

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PHYSIOLOGY OF ANIMALS

VARIOUS PARTS OF THE ANTERIOR LOBE OF THE PITUITARY BODY AND THE PHYSIOLOGY OF LACTATION

By G. I. AZIMOV and A. D. ALTMAN

(Communicated by I. I. Schmalhausen, Member of the Academy, 20.VII.1938)

As far back as in 1892 Schönemann (1) found the anterior lobe of the pituitary body to be built of three kinds of cells: reserve (chief cells), eosinophilic and basophilic cells. One succeeds to observe by macroscopic examination of sagittal sections of the anterior lobe of the pituitary body of cattle quite dissimilar regions. One of them, the central one, which is nearer to the posterior lobe, is comparatively small and distinguished by its reddish colour, due to considerable vascularization and the compact consistence of tissue in this region. Basophilic and reserve cells are present, while eosinophils are totally absent. The rest of the anterior lobe of the pituitary body consists of all the three kinds of cells, the eosinophils prevailing, especially on the periphery (2, 3).

Which of these cells are involved in the secretion of the hormones of the anterior lobe of the pituitary body?

Nowadays we dispose of an abundant experimental material as to the place of secretion of the hormone of growth, as well as of the thyreotropic and gonadotropic hormones. Especially abundant data have been collected by Woitkewitch(4) who succeeded in demonstrating that the growth hormone is connected with the activity of the «eosinophilic zone», while the secretion of the thyreotropic and gonadotropic hormones is connected with the «basophilic zone». And yet no literary data are available with regard to the place of secretion of the lactogenic substances of the anterior lobe of the pituitary body.

To make clear this question we undertook several series of experiments.

We isolated with utmost scrupulosity from a freshly frozen gland of cattle the basophilic and the eosinophilic zones. Out of 100 g of glands may be obtained about 4.0—4.5 g of cells of the basophilic zone. All this meticulous work was performed at low temperature.

From separate zones of the anterior lobe of the pituitary glands thus isolated lactogenic preparations were made; ground glands were first treated with $Ba(OH)_2$ and then subjected to partial neutralization with 0.2 N H_2SO_4 till a pale pink colour for phenolphtalein. A preparation of the total anterior lobe of the pituitary body was made to serve as control using the same procedure. All the three hormones were in the first place tested on pigeons. The hormones under test were applied once daily for 4 days in the pectoral muscles. On the fifth day the crop of the pigeon was dissected, the growth of the crop glands as well as the presence of the «crop milk» being recorded.

The increase of the weight of the crop due to the injection of lactogenic hormone was also studied. For this purpose the pigeons were killed after the fourth injection, the crop carefully extirpated and weighed together with its content. The comparative activity of the preparations was tried on guinea pigs too, in which the result was evaluated in counting the drops of milk that could be squeezed out of the nipples. Finally, the activity of the «eosinophilic preparation» was checked on cows, by the increase of the milk yield upon a subcutaneous injection of 50 cm³ of the preparation.

Table 1

The Appearance of the Crop Milk (Riddle-test) in Pigeons as Influenced by Lactogenic Hormone (Prolactin) from Different Zones of the Anterior Lobe of the Pituitary Body*

№ of the series and date of experiment	Number of birds per exper.	Preparation injected														Note
		Basophilic cells					Eosinophilic cells					Total preparation				
		Efficiency evaluation														
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5**
		Number of pigeons														1 pigeon of the eosinophil. group perished (exp. 2)
1. 13. II.1937	9	—	—	2	1	—	—	—	—	1	2	—	—	—	2	1
2. 19. III.1937	9	—	—	3	—	—	—	—	—	2	—	—	—	2	1	—
3. 11. V.1937	9	2	—	—	—	—	—	—	—	2	1	—	—	—	3	—
4. 20. VIII.1937	9	—	—	3	—	—	—	—	—	1	2	—	—	—	1	2
5. 16. X.1937	21	1	4	2	—	—	—	—	2	4	1	—	—	3	4	—
6. 25. XI.1937	9	—	2	1	—	—	—	—	—	3	—	—	—	1	2	—
Average		2.4					4					3.7				

* Dosage—1 cm³ daily during 4 days.

** 1. No changes in the condition of the crop glands—prolactin is absent.
2. The crop walls not thickened, but covered with a greyish coat—dubious results.
3. The crop walls somewhat thickened and covered with clots of crop milk—slight activity.
4. The crop walls thickened and covered with crop milk—active preparation.
5. The crop walls considerably thickened, almost the whole crop filled with crop milk—highly active preparation.

Results of the Experiments

On the whole the three above-mentioned lactogenic hormones have been tested on 95 pigeons.

From Table 1 one may see that when an extract of basophilic cells is injected, the state of the crop is evaluated as 1, 2, 3. In case of injection of the extracts of the eosinophilic or the total preparation, we nearly always could evaluate it as 4, 5 and only occasionally as 3 (in the case of total preparation). The results obtained with the basophilic preparation in the first series should obviously be accounted for by the fact that in this case the basophilic cells failed to be carefully isolated from the eosinophilic ones.

These data are confirmed by the results obtained by means of weighing the crops of the pigeons (Table 2).

Table 2

Weight of Crops of the Pigeons Injected with Lactogenic Preparations from Different Zones of the Anterior Lobe of the Pituitary Body (in g)

Preparation injected								
Basophilic cells			Eosinophilic cells			Total preparation		
Weight		Ratio of crop weight to body weight	Weight		Ratio of crop weight to body weight	Weight		Ratio of crop weight to body weight
Pigeon	Crop		Pigeon	Crop		Pigeon	Crop	
320	5.1	1.59	330	7.3	2.21	345	10.5	3.04
295	3.9	1.32	295	5.7	1.93	281	4.5	1.6
365	4.7	1.28	350	7.5	2.14	355	5.4	1.52
Average								
327	4.56	1.39	325	6.83	2.10	327	6.8	2.09

The data given in Table 2 point to that the pigeons injected with basophilic preparation prove to have the minimum crop weight (4.56 g), while the weights of crop in pigeons, treated with eosinophilic or total preparations, are nearly the same (6.83 and 6.80 g). The ratio of the weight of crop to that of the body gives similar results.

As the basophilic zone of the anterior lobe of the pituitary body contains a greater number of blood-vessels and correspondingly less cellular elements, one may assume that the results obtained are due to an insufficient dose of the preparation injected of the «basophilic zone». To exclude this assumption, we undertook a special experiment in which the doses of the preparation injected were increased. This experiment showed that the increase of the dose of the basophilic preparation to 1.5 cm^3, the doses of eosinophilic and total preparations being simultaneously reduced to 0.5 cm^3, did not affect the results previously obtained (Table 3).

Table 3

Comparative Effect of Various Doses of Lactogenic Preparations from Different Zones of the Anterior Lobe of the Pituitary Body

№ of the series and date of the experiment	Number of pigeons per experiment	Dosage in cm^3	Preparation injected														
			Basophilic cells					Eosinophilic cells					Total preparation				
			Efficiency evaluation														
			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
			Number of pigeons														
4. 4.VIII.1937	9	0.5	3	—	—	—	—	—	—	—	2	1	—	—	—	1	2
7. 25.XI.1937	6	0.5	—	—	—	—	—	—	—	—	2	1	—	—	—	1	2
7. 25.XI.1937	3	1.5	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 4

The Effect of Lactogenic Preparations from Various Zones of the Anterior Lobe of the Pituitary Body upon Guinea Pigs (dosage 2 cm³ per day)

№ of the series and date of experiment	Number of guinea pigs per exper.	Duration of treatment in days	Preparation injected									Note
			Basophilic cells			Eosinophilic cells			Total preparation			
			Negative results	Colostrum	Milk	Negative results	Colostrum	Milk	Negative results	Colostrum	Milk	
			Number of guinea pigs									
1. 13.II 1937 . .	6	5	4	—	—	1	—	—	—	—	1	Pigs of the basophil. group perished
3. 11.V 1937 . .	6	9	2	—	—	—	1	1	—	2	—	Same
12. 26.XI 1937 . .	7	10	3	—	—	—	—	2	—	—	2	Same

As we have already mentioned, we tested the three extracts prepared from different parts of the pituitary, besides pigeons, on guinea pigs and rabbits. However, in injecting the basophilic preparation to guinea pigs and rabbits we came across some specifities of its action upon the organism of these animals. While the eosinophilic and total preparations produce in guinea pigs and in rabbits a secretion of milk or milky substance (Table 4), the second injection of the basophilic preparation inevitably leads to the death of guinea pigs. The rabbits perished only after an increased dose of the basophilic preparation*.

Table 5

Effect of Treatment with the Eosinophilic Preparation upon the Production of Milk in Cows (injection made on 23.XI 1937)

№ of cows	Milk yield 5 days before injection (in l)						Milk yield after injection (in l)						Increment per 5 days
	1st day	2nd day	3rd day	4th day	5th day	5 days	1st day	2nd day	3rd day	4th day	5th day	5 days	
1 . . .	14.5	14	13	14	13.5	69	15.25	15.25	15.75	16.75	18	81	12
575 . . .	9.5	9.5	11	11.5	11.5	53	13	13.75	13.5	14.25	12.5	67	14
227 . . .	10	9.5	10.5	11	11.5	52.5	12.25	14.25	14.5	14.25	14.25	70	17.5
836 . . .	9	8	10	10.5	11	48.5	11.25	12.5	12.75	12.5	11.25	60.25	11.75
69 . . .	11	10	8.5	11	11.5	62	14	15.25	15.25	15.75	15.75	76	24
1827 . . .	6.5	8	7.5	7.5	8	37.5	8.5	9.25	9	9.25	7.75	43.75	6.75
1772 . . .	7.5	8	7.5	7	7.5	37.5	8	8.5	9.5	9.5	8.5	44	6.5
278 . . .	10.5	10	9.5	10	8	48	11	11	11	12.5	12	57.5	8.5
762 . . .	5	5	6.5	6	7	29.5	7.5	6.5	7.5	7	6	34.5	5
921 . . .	8	6	7.5	8	7	36.5	9	10.5	10.25	10.75	10	50.5	14
252 . . .	10	10.5	10	10	10	50.5	11.25	12	12.5	11.5	11.5	59.25	8.75

* These data will be published in a special communication.

The eosinophilic preparation has also been tested on cows. 11 cows have received 50 cm^3 of this preparation, while 89 cows of the same farm were injected with 50 cm^3 of the total preparation. Cows showing similar zootechnical values but not subjected to treatment with pituitary body preparation used as controls (Table 5).

From Table 5 it may be seen that increase in milk yield in cows injected with the eosinophilic preparation amounted to 128.25 l for 5 days, or, on the average, 11.75 l per animal. The increase in milk yield in cows treated with the total preparation made up 7.1 l per animal. The group of non-treated cows, naturally, exhibited no increase in milk yield (for lack of space we omit respective data). This experiment shows that the extracts prepared only from the eosinophilic cells do produce a positive effect on the milk yield in cows ([5]).

We do not dwell here upon the question of numerous hormones secreted by the anterior lobe of the pituitary body. Yet even sceptics believe it to contain no less than 3 independent hormones, the lactogenic, gonadotropic and thyreotropic ([6]). Woitkewitch's experiments contain convincing material showing that the gonadotropic and thyreotropic effects are connected with the basophils. Our experiments permit of referring the lactogenic effect rather safely to the function of the eosinophilic cells of the anterior lobe. This is first of all supported by the results obtained on pigeons and guinea pigs. The so-called reserve cells, scattered all over the anterior lobe of the pituitary body, do probably not affect the lactogenic effect of the eosinophilic zone, since it is familiar that the tissues chiefly made up of reserve cells give the poorest effect ([7]). An indirect proof of a close relation between the eosinophils and the lactogenic process may be possibly found in the fact that the lutheinization of the ovaries which in some mammals inhibits the phenomena of lactation, is more easily produced by introducing extracts of the basophilic part of the anterior lobe of the pituitary body, than that of the eosinophilic one ([7]).

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DEVELOPMENT MECHANICS

GROWTH OF EMBRYONAL TISSUE IN VITRO AS INFLUENCED BY AN EXCESS OF CHLORIDES (Na, K, Ca)

By A. V. RUMJANTZEV

(Communicated by I. I. Schmalhausen, Member of the Academy, 16.VII.1938)

Immersion of bits of tissues into solutions of various salts possesses, as a method for studying the action of salts on protoplasm, a number of inherent defects. The results obtained by this procedure can hardly be regarded as holding true for the organism as a whole, since in the latter the changes taking place in the salt composition are always expressed in a disturbance of the existing relation between salts, i. e. the increase or respectively decrease of the quantity of a certain salt always takes place in the presence of a number of other salts.

More reliable results in this respect can be obtained by studying the action of salts on tissue cultures, in which the conditions of the experiment are always nearer to the physiological ones.

Proceeding from this standpoint, we deemed it of interest to analyse in detail the action of NaCl, KCl and CaCl on the growth, metabolism and morphological alterations of tissue growing in vitro. We are no pioneers in this field. M. and W. Lewis, Olivo, Mendeleeff, Biscelie and Bucciardi, Krontowskaja, Demuth, Knake, Verne in their time, and recently Möllendorff and Grossfeld have tested the influence of various salts on cells growing in vitro. A special interest is presented for us by the works of Krontowskaja and of Demuth, who describe a decrease of the size of cells under the influence of $CaCl_2$ to almost half the size of the control cells. As to KCl, Biscelie and Bucciardi in their time and recently Möllendorff established a definite swelling effect of this salt, giving rise to an intense vacuolization of the protoplasm.

The purpose of the present work was 1) to study the general character of growth and 2) to establish, if possible, the eventual presence of a specific prolonged action of an excess of different salts on growing tissue.

Material and Procedure. Heart tissue of 6—8 days old chicken embryos was cultivated in a medium, composed by 1 part of plasma and 2 parts of the solution under test. The following solutions ware tested: NaCl —0.9 p. c., KCl—1. 11 p. c., $CaCl_2$—1.26 p. c. The bits of tissue were cut in the solution under test and kept in it for 30 min. Cultures in plasma, diluted with Ringer's solution, were used as controls. Growth was evaluated by the increment of the area according to the method of Ebling. For judging of the size and shape of cells we measured two diameters of their nuclei. Since the shape of the nucleus corresponds in most cases to that of the

cell (elongated cells—long ellipsoid-shaped nuclei; flattened out stellar cells—round large nuclei), the ratio of the two diameters permitted to judge of the shape of the nucleus respective of the cell and the product of the diameters of their relative size. A total of 960 cultures including 400 control ones were used.

Results of Observations. We know that normally 1—2 p. c. of such tissue cultures produce no growth. Counts of cultures which did not grow or produced weak growth (out of 300 for each salt) gave for NaCl-cultures 5 p. c., for KCl ones 12 p. c. and for $CaCl_2$ 20 p. c.

At first we were inclined to ascribe this to the toxicity of the salts. However, having transplanted the bits which failed to grow into the normal medium, we obtained growth. Evidently, this phenomenon depends on a different cause, possibly in the first place on the character of the clot.

The results of the measurements of the absolute tissue increment par day are shown in Table 1. It is evident from this table, that the excess of NaCl does practically not delay growth during the first two days, while KCl and $CaCl_2$ do retard it. By the 3rd day of cultivation the highest growth delay is observed in $CaCl_2$-cultures. Comparing, however, the zone of increment with its density (i. e. the number of cells in the zone), one can easily see that this zone is considerably denser in cultures with $CaCl_2$ than in those with KCl. The effect of NaCl as compared with the controls is practically nil. Studying the genetral character of the cellular material and the formation of the cells in the zone of growth, one can see that the superficial zone of control cultures is composed by typical cells. In cultures with NaCl or KCl added the growth proceeds chiefly along the glass slide, the zone of ingrowth into the plasma being usually but slightly expressed. In cultures with $CaCl_2$ growth proceeds in every direction and into the plasma of the medium equally. Since it has been proved that the character of the cells is determined by the density of the clot (Weiss, Grossfeld), it follows that KCl does not favour the formation of a dense fibrin network, this in part determining the shape of the cells. In NaCl-cultures the cells during the first two days do not differ from those of the control cultures either in shape or in the manner in which they are bound one with another, but on the third day arise large cells with a vacuolized protoplasm.

Table 1

Ratio of Two Altered Diameters of the Cell Nuclei in the Zone of Growth

Culture	N	$M \pm m$
Control	230	2.0 ± 0.04
NaCl	248	2.1 ± 0.04
KCl	234	2.0 ± 0.05
$CaCl_2$	256	2.5 ± 0.06

Cultures with KCl manifest a clear tendency towards the formation of a membrane, composed by polygonal cells alone, the vacuolization of their protoplasm being manifest as early as by the end of the first day, while by the third day the vacuolization of the majority of cells is quite demonstrative. In $CaCl_2$-cultures one encounters in the zone of growth alongside of polygonal and stellar-shaped cells many elongated cells; some angular cells, however, are also found in them. As a rule, cells in $CaCl_2$-cultures are united by well noticeable fine processi and form a characteristic felt-like mass of tissue, while in KCl ones the cells show a trend towards forming a hyaline ectoplasm and separating from each other.

As Dagliotti, Wermel and Ignatieva have earlier noted, the size of the cells and of their nuclei in the cultures varies. We studied only nuclei, assuming, that though there is no precise relation between the size of the nuclei and that of the cells (cf. Dagliotti), still large nuclei are always characte-

ristic of large cells and vice versa. We measured some 25—30 nuclei per zone in the growth zones of 10—15 cultures for each series. By computing the results we found that the average value of the ratio of the two diameters is practically the same in the controls and in the NaCl- and KCl-cultures, showing a 20 p. c. increase in the direction of elongation in $CaCl_2$-cultures as compared with controls.

As shown by subsequent analysis, this elongation of cells depends on their growing in a denser clot of the plasma and on the specific effect of $CaCl_2$, which exerts an inspissating effect on the protoplasm of the cells.

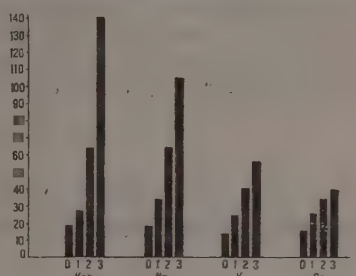

Fig. 1. Average of 300 measurements for each salt. Cultures without embryonal extract. *0*—size at the moment of transplantation, *1*, *2*, *3*—days. Kon—control cultures.

However, these data supply no information as to the size of the nuclei which would necessitate measurements of their volume. Since in the zone of growth the superficial cells grow extending over the mica, the third diameter of their nuclei, which is necessary for determining their volume, is very small and it is impossible to measure it accurately. Therefore we can neglect it, assuming it to be approximately the same in all nuclei, and compare only the products of two diameters, i. e. practically substitute the surface area of the rectangle, into which the nucleus is inscribed, for the size and volume of the nucleus. Variation ranges of these surface areas, arranged for each series, supplied us the following results (Table 2).

Table 2

Cultures without Embryonal Extract

Cultures	N	$M \pm m$	$C\%$	$Q\%$*
Control	294	50.9 ± 1.24	41	—
NaCl	422	52.0 ± 1.64	64	+ 2.2
KCl	388	48.9 ± 1.11	51	— 3.9
$CaCl_2$	394	30.9 ± 0.6	40	—39

Similar results were obtained also for cultures in which a minimum quantity of embryonal extract had been added to the medium (Table 3). The curves, drawn for obtaining the variation ranges, demonstrate graphically the changes taking place in different cultures. First of all they are asymmetric and excessive. The curves for NaCl-cultures are the nearest to those of the controls. The curve for $CaCl_2$ shows the highest peak. KCl

Table 3

Cultures with a Small Amount of Embryonal Extract

Cultures	N	$M \pm m$	σ	$C\%$	S	$Q\%$
Control . .	400	52.7 ± 1.2	24.02	45	1.11	—
NaCl . . .	300	46.7 ± 1.1	19.1	41.5	1.3	—11.3
KCl	400	49.1 ± 0.9	19.02	38.8	1.2	— 6.8
$CaCl_2$ . . .	400	33.6 ± 0.7	15.64	47.4	1.08	—36.2

* In the figures for Q, i. e. of the p. c. change of the size of nuclei as compared with that in the controls, we denoted the p. c. increase by the sign plus (+) and the p. c. decrease by the sign minus (—).

occupies an intermediate position. The entire curve for $CaCl_2$ is displaced towards the left, a considerable decrease taking place in the size of the cavities as compared with those of the control cultures (practically by 40 p. c.) and consequently also a decrease of the cell size. Analysing these ranges, we are led to the conclusion that the difference between the values of $M_{control}$ on one side and M_{Na} and M_K on the other is not significant, while the ratio calculated for M_{Ca} shows a significant difference

$$M_{control} - M_{Na} \pm \sqrt{\sum m^2} = \frac{1.08 \pm 1.03}{1.1 : 1},$$

$$M_{control} - M_K \pm \sqrt{\sum m^2} = \frac{3.45 \pm 1.52}{2.3 : 1},$$

in both cases the difference is insignificant.

$$M_{control} - M_{Ca} \pm \sqrt{\sum m^2} = \frac{29.10 \pm 1.43}{19.3 : 1},$$

a significant difference.

In view of the alterations observed in the nuclei which become elongated in $CaCl_2$-cultures as well as of the regularly observed density of the growth zone in them, one is inclined to assume that $CaCl_2$ promotes specific alterations, expressed in a simultaneous elongation and size decrease of the cells. This can in the first place be referred to dehydration of the protoplasm. As to NaCl- and KCl-cultures, growth in them is almost identical with the normal. However, the early vacuolization of the cells in the presence of KCl indicates an intense hydration of the protoplasm.

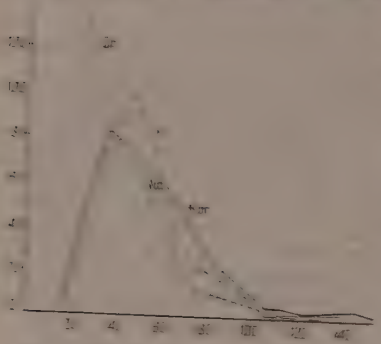

Fig. 2. Variation curves of cell-size in the cultures with different cations. Abscissa: size — ordinate: number.

Summary. 1. Excess of NaCl does not noticeably tell on the character of the growth of tissue. Excess of KCl produces an apparent tendency towards the formation of membranes, composed by separated polygonal cells; these polygonal cells become in short time vacuolized, this being a sign of the hydration of their protoplasm and later on even of a deeper alteration of the liquid phases.

Excess of $CaCl_2$ gives rise to alterations in the shape of the cells. Long, cylinder-shaped or angular cells appear in the zone of growth. They are united by true processes. The zone of growth is dense, felt-like. The number of the cells becomes increased (by 20—25 p. c. on the average), while their size (judged by their areas) decreases by 40 p. c. as compared with the controls. The absence of vacuolization and the size decrease mentioned above point to a marked dehydration of the cell protoplasm.

2. The formation of a dense felt-like zone of growth in $CaCl_2$ and the marked tendency of the cells to become united and to lose the ability to exist as such, unless in contact, show that $CaCl_2$ is necessary for uniting the cells into a syncytium, as it is for uniting the blastomeres. We see in this respect a great resemblance of our observations with those of Driesch, who, by his well-known experiments in his experiments with the dissociated tissue of sweet-water sponges.

3. The experiments established that chlorides manifest a certain specificity in their action on tissue growing in vitro, even when one of the cells is placed in quite a different way than the others. This gives us the right to interpret

the phenomena observed in cultures with these taking place in the organism, where, according to the data obtained by Kaiser in experiments on frogs, excess of K-ions provokes a swelling of tissue, while excess of Ca leads to an impoverishment of the surface membranes of the cells.

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DEVELOPMENT MECHANICS

THE EFFECT OF THE ACTION OF THE SUBSTANCE FROM VARIOUS ZONES OF THE ANTERIOR LOBE OF THE HYPOPHYSIS IN CHICKEN

By A. A. WOITKEWITSCH

(Communicated by I. I. Schmalhausen, Member of the Academy, 14.VI.1938)

The investigation of the principle hormones of the hypophysis, determining among others the function of such important components of the endocrine system as the thyroid and the sexual glands, has considerably advanced the solution of the question concerning the influence of the hypophysis on form-building processes. The most detailed study in this field has been done on amphibiae and mammals, which yielded quite accurate data both with regard to growth stimulation and thyreo- and gonadostimulation. In birds, on the contrary, no definite results have been so far obtained.

An analysis of the literary data available on the action of the anterior lobe of the hypophysis in birds shows that practically no growth stimulation was obtained, while the existence of a gonadotropic effect still remains rather questionable. Only the thyreotropic effect of the anterior lobe of the hypophysis proves to be supported by sufficiently convincing data.

Owing to our previous investigations dealing with the problem of localization of the principle hormones of the anterior lobe ([2], [3], [4], [5]) the conflicting assumptions as to its effect on the growth and development of bird genades might have found their solution. These divergencies might be due, first, to the different procedures of treatment and insertion of the anterior lobe, and, secondly, to the heterogeneous structure of the anterior lobe of the hypophysis of mammals (cattle), usually applied in the experiments of this kind. We have succeeded to show in amphibiae and mammals ([6]) that the morphogenetic effect depends on the parts of the anterior lobe used for the test. The tissue of the anterior lobe rich in eosinophiles (peripheral part) exerted during these experiments a growth stimulating effect. The central part of the organ, mostly built up of basophiles, proved to possess a gonadotropic and thyreotropic action. On account of that and with the purpose to make clear the nature of the effect of the anterior lobe of the hypophysis upon the development of the bird and to explain the conflicting data, we undertook experiments involving separate tests of the basophilic and ecsinophilic part of the anterior lobe.

The first group of experiments was performed using as material chickens of White Leghorns. As in our previous experiments, we used for implantation fresh cattle hypophysis taken from the slaughterhouse. 20 chickens were given the tissue of the basophilic zone, 20 — that of the eosinophilic one, while 20 served as controls (grafting of bits of muscle tissue of corresponding size). The implantation was performed in all birds simultaneously, beginning from the age of two days, and being repeated every six days. The amount of the tissue inserted at subsequent transplantations was correspondingly

increased with the growth of the chickens in the ratio 2 mg of hypophyseal tissue per 1 g of live weight. The total duration of the experiment was 90 days. The weights that were registered and treated for males and hens separately. The average figures obtained are given in Table 1.

Table 1

Growth of Chickens (Weight in g) Grafted with the Substance of Different Zones of the Anterior Lobe of the Hypophysis

Days passed since the 1st graft	♀♀			♂♂		
	Control	Basophilic zone	Eosinophilic zone	Control	Basophilic zone	Eosinophilic zone
0	43.0	42.9	42.5	43.0	42.6	42.5
6	50.9	45.7	50.3	50.9	51.2	50.7
12	60.8	55.5	70.0	63.0	61.2	62.7
18	74.2	70.8	86.0	76.2	75.7	85.4
24	105.0	83.4	115.6	101.4	96.2	134.5
30	142.3	116.8	168.5	146.2	145.0	178.4
36	192.3	164.2	232.0	215.5	200.6	247.0
42	247.3	214.8	335.0	275.6	254.0	338.0
48	308.0	279.1	440.0	350.0	326.7	441.0
54	396.8	321.6	396.0	440.8	378.3	451.7
60	389.0	360.1	439.0	442.0	440.0	502.4
66	451.0	417.8	521.7	585.1	509.2	601.0
72	563.5	495.0	614.9	655.0	596.4	706.0
78	630.4	551.2	694.2	752.6	690.5	821.4
84	708.5	614.0	754.8	855.4	829.0	935.3
90	779.0	685.0	822.0	952.0	912.0	1 060.7

From the table may be seen that the growth of the chickens which had received the substance from the basophilic zone is depressed, while the im-

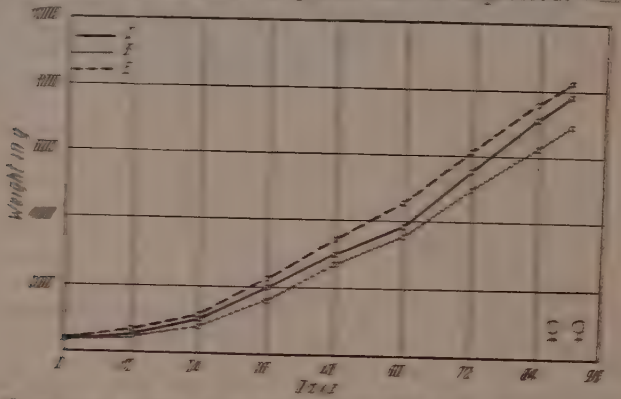

Fig. 9. Growth of hens grafted with the substance of different zones of the anterior lobe of the hypophysis. C—control, B—basophilic zone E—eosinophilic zone.

plantation from the eosinophilic zone is rather followed by growth stimulation (Fig. 9). Thus, as had already been experimentally found for amphibians, growth stimulating action is inherent to the eosinophilic zone alone. The insertion of the basophilic zone, on the contrary, has a rather inhibiting effect upon growth. The effect is more pronounced in hens, while in cocks the influence is less noticeable.

Similar results were obtained from an additional series consisting of 50 Rhode-Islands. However, we failed to detect any stimulation of growth in

young pigeons and ducklings grafted with the eosinophilic zone. The weight of ducklings belonging to different series was identical during the 48 days of the hypophysis implantation that was performed with a 6 day interval. 15 days after the end of grafting the ducklings from the series which had been given the basophilic zone, were found to exceed the rest in weight (325 g on the average). It is noteworthy that such an «after-effect» was observed on Leghorn-cocks too 15—20 days after the end of grafting. Alongside of their inhibitory effect upon growth, the basophilic elements stimulated the processes of differentiation, viz. sexual maturity and development of the plumage. Fig. 2 shows that while the basophilic zone calls forth a hypertrophy of the testes, the eosinophilic zone inhibits their development.

Fig. 2. The cock on the right was grafted with the basophilic zone, that on the left—with the eosinophilic zone (reduced 5 times). Below the testes of the same cocks (natural size).

The ability of the hormones localized in the basophilic zone to produce gonadotropic and thyreotropic effect was made evident by another group of experiments too. In this case White Leghorn hens at the age of $3^1/_2$ months served as material. Eight of them were grafted with the substance of the basophilic zone, and 5 with that of the eosinophilic one, while 4 hens served as controls. The results are shown in Table 2.

Table 2

Weight and Structure of the Thyroid Glands (One Lobe) of Young Hens

Series	In 5 days				In 10 days			
	Thyroid gland			Ovary in mg	Thyroid gland			Ovary in mg
	Weight in mg	Ephithelium height in μ	Diameter of follicles in μ		Weight in mg	Epithelium height in μ	Diameter of follicles in μ	
Control	37.6	5.93	38.48	369.0	36.7	6.71	39.79	445.8
Basophilic zone .	49.0	9.05	38.02	503.5	44.2	9.76	49.79	998.1
Eosinophilic zone	20.2	4.04	37.11	348.4	35.1	7.10	54.15	481.0

The data tabulated above first of all point to the presence of a well pronounced thyreotropic effect produced by the substance of the basophilic zone of the anterior lobe of the hypophysis. The hyperfunction of the organ sets in by the 5th or 10th day. The insertion of the substance from the eosinophilic zone produces at first (after 5 days) a certain depression of the thyroid gland which later on decreases.

The data available as to the weight of the ovary in case of insertion of

the basophilic zone point to the presence of a gonadotropic effect in the hens of this series, the size of the follicles beginning to increase already by the 5th day, while on the 10th day the effect becomes still more pronounced.

These data throw light on the «after-effect» observed in chickens and ducklings after the cessation of grafting with the basophilic zone of the anterior lobe, which permits of an interpretation of this phenomenon. It should be assumed that the hormone of the thyroid gland, penetrating into the blood in an increased quantity, exerts a depressing action upon the growth directly after implantation. Larionov[8] observed an inhibition of growth on chickens to whose rations had been added small amounts of thyreoidine. However, as soon as the administration of thyreoidine had been cut off, the intensity of growth in these birds proved to exceed the standard. In our experiments we observed similar relations which should evidently be put down to an original activation with the birds own thyroid gland. It is necessary to note a sharp increase of the testes in cocks, taking place after the cessation of graftings with the basophilic zone of the hypophysis (Fig. 2). In this case a certain analogy with experimental thyreoidization may be traced. It is familiar that continuous thyreoidization inhibits the development of gonads, while small doses of a thyroid preparation or of thyroxine have a stimulating effect[1, 7].

In connection with the data obtained we are justified to assume that the conflicting results of our predecessors in the study of the influence of the hypophysis on the development of birds, were, at least partly, due to the use of preparations or extracts from the whole anterior lobe.

Taking into account the variable dimensions of the zones, especially of the basophilic one, as well as the possibility of a higher degree of decay in the course of treatment of some elements as compared to others, it is natural enough that the preparation may possess different properties. It may either stimulate the development of the gonads, or produce the opposite effect.

In the results of the given investigation we once more find a confirmation of the assumption previously generalized as to the existence of a relation between the two basic elements of the development of an animal organism, viz. growth and differentiation, and the activity of the basic cellular elements of the anterior lobe of the hypophysis. The periods of intense growth and differentiation, disagreeing in time, are activized by antagonistic hormones produced by different cellular elements of the anterior lobe. It may be assumed that this complex system of the process of development as a whole being regulated by the hormones of the hypophysis arose in the course of phylogenesis at the moment of distribution of functions among its separate elements.

Our suggestion should not be interpreted as an attempt to attribute the regulating power in the processes of growth and differentiation to the hypophysal hormones alone. A feature characteristic of the influence of the glands of internal secretion on biological processes is the complexity of the action. And yet, among all consecutive conditions responsible for the growth and differentiation of the organism during the post-embryonal period, the rôle played by the hormones of the hypophysis is a most important one.

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